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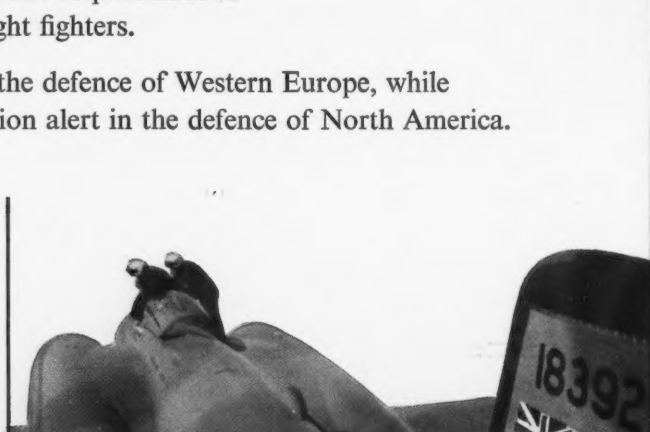

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9-56

To NATO from Canada

Camouflaged in official NATO colors and proudly flying the Canadian Ensign on their tails, the first Royal Canadian Air Force squadron of AVRO CF-100's to join NATO air defence in Western Europe, departs for its base in France.

This flight, the first of several scheduled to hop the North Atlantic this year, is Canada's response to a specific requirement of NATO for all-weather, night fighters.

It is one more of Canada's contributions to the defence of Western Europe, while continuing round-the-clock interception alert in the defence of North America.

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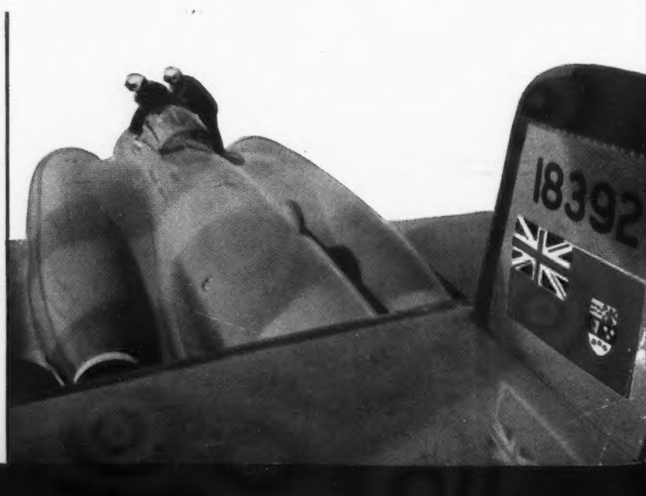

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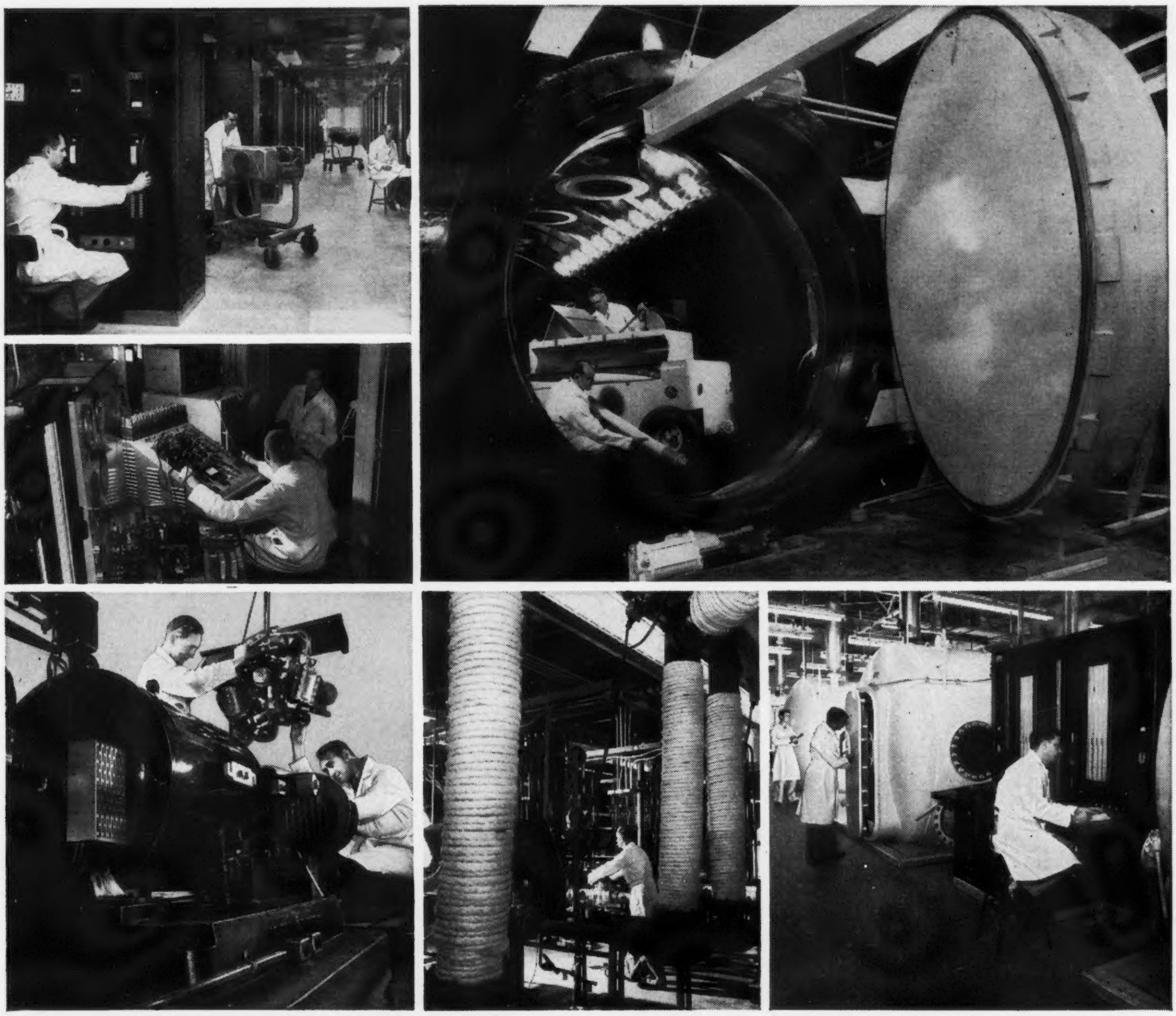
9-56

EDITORIAL BOARD

The Editorial Board for 1956-57 has been appointed as follows. Others may be added later as need arises.



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OTTER AT 50° BELOW

By fitting wooden covers over the front of the cowling and introducing hot air from a Herman Nelson heater, the Pratt & Whitney R1340 engine of the De Havilland Otter can be thawed out, ready to start, in one hour.

EDITORIAL

INTERNATIONAL GEOPHYSICAL YEAR

The International Geophysical Year, to take place in 1957/58, consists of a co-ordinated effort by 40 nations to advance the world's knowledge of the physical phenomena of the earth. Geophysics is defined as the study of all the physical properties of the earth from the centre of the earth to the top of the atmosphere. Thus geophysics includes geodetics (the shape of the earth), meteorology, atmospherics, magnetics, gravity, aurora etc. While much of the research contemplated in the I.G.Y. is basic, it is not difficult to see that the lessons learned could materially affect many aviation activities and this is particularly true as we advance higher and faster.

One of Canada's important assignments is to study the aurora and its relation to magnetic disturbances. To do this, special auroral recorders coupled to recording magnetometers have been designed and built in Canada, which record both sets of phenomena continuously on a single punched tape against time. Such stations will be established across the North and much should be learned from the subsequent analysis of the tapes. Other nations will be setting up similar stations in the Antarctic so that the coincidence of activity, if any, at both ends can be established.

Canada is commonly supposed to be the home of mining geophysics. What is not so generally known is the extent to which mining geophysics have become airborne. Prior to 1950 most mining geophysics, the science of using the physical properties of rocks to locate ore, was carried out on the ground. The cost was so high that the methods could only be applied to small areas, using geological reconnaissance methods to pinpoint the areas for subsequent geophysical study. However by 1950, as a result of post-war research, increasing numbers of geophysical instruments were developed which could be carried in aircraft, starting with magnetometers to measure the magnetic permeability of rocks, radiation counters to measure radioactivity and finally electro-magnetic instruments to measure electrical conductivity.

These air methods, the majority of which have been developed and pioneered in Canada, have quite literally revolutionized exploration methods, besides resulting in a greatly increased rate of successful ore discovery. Through the air methods, the role of geophysics in exploration has reversed and now the tendency is for large areas to be "flown" by the rapid and economical airborne geophysical methods and, based on the data secured, for detailed geological studies on the ground to follow up.

Today there is more mining geophysics being carried out in Canada than in any other country and of this total, in terms of dollar volume, some 70% is airborne.

Naturally the existence of the I.G.Y. is having the effect of broadening public interest and information not only in basic geophysical research, epitomized by the earth satellite, but also increasing interest in its applied fields such as mining geophysics. This is certainly commendable.

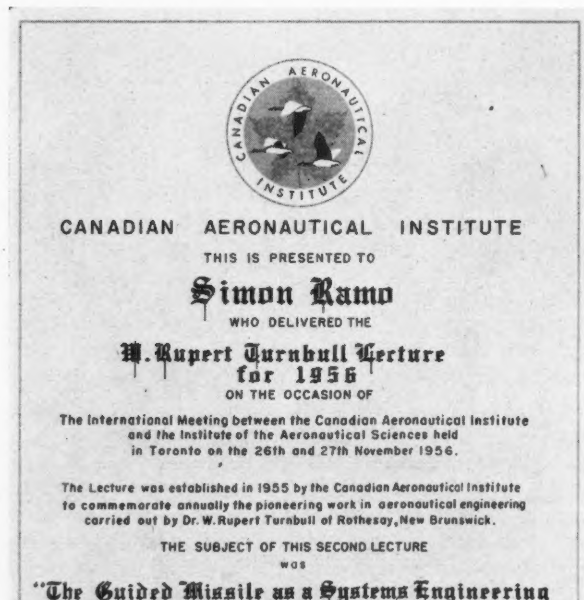
D. N. Kendall
President
PSC Applied Research Ltd.

W. RUPERT TURNBULL LECTURER

Dr. Simon Ramo

Dr. Simon Ramo, Executive Vice President, The Ramo-Wooldridge Corporation, delivered the second W. Rupert Turnbull Lecture on the 26th November, 1956. Dr. Ramo has prepared a slightly abbreviated version of his text for publication in the Journal; it will be published in two parts, the first of which appears in this issue.

Dr. Ramo was born in Salt Lake City in 1913 and is a graduate of the University of Utah. He obtained his Ph.D. in Electrical Engineering and Physics from the California Institute of Technology. After ten years of electronics research and development on the staff of General Electric, he joined the Hughes Aircraft Company in 1946, where he became Director of Guided Missile Research and Development and later Vice President and Director of Operations. He is now Executive Vice President of the Ramo-Wooldridge Corporation, one of the leading corporations in electronics and in the ballistic missile programme of the United States. Dr. Ramo has been active in academic as well as in industrial work and he has written extensively in the fields of physics and electronics. He has served on the staff at Union College and in graduate courses at the California Institute of Technology. He is a member of the Scientific Advisory Board of the U.S.A.F.



CANADIAN AERONAUTICAL INSTITUTE

THIS IS PRESENTED TO

Simon Ramo

WHO DELIVERED THE

W. Rupert Turnbull Lecture for 1956

ON THE OCCASION OF

The International Meeting between the Canadian Aeronautical Institute and the Institute of the Aeronautical Sciences held in Toronto on the 26th and 27th November 1956.

The Lecture was established in 1955 by the Canadian Aeronautical Institute to commemorate annually the pioneering work in aeronautical engineering carried out by Dr. W. Rupert Turnbull of Rothesay, New Brunswick.

THE SUBJECT OF THIS SECOND LECTURE was

"The Guided Missile as a Systems Engineering Problem"

DATE: 26TH NOVEMBER 1956

T.E. Stephenson
PRESIDENT

SECRETARY

THE GUIDED MISSILE AS A SYSTEMS ENGINEERING PROBLEM†

by Dr. Simon Ramo*

The Ramo-Wooldridge Corporation

This lecture is concerned with two topics in modern engineering – guided missiles and systems engineering. Each is receiving an increasing amount of attention by both the scientific and the industrial community. By connecting these two topics, the lecture seeks to improve somewhat the understanding of both.

The guided missile is probably the most discussed single item in modern technology today. Interest in this field may even surpass that in nuclear matters, probably because it is understood that guided missiles may involve nuclear components and thus the guided missile field is the broader of the two. Despite the fact that military data pertaining to guided missiles are classified, enough unclassified information exists and enough uninhibited curiosity is exhibited so that guided missiles are discussed with increasing frequency in virtually every type of publication and before all classes of technical and non-technical meetings. To the aeronautical engineer, the guided missile represents an extension of familiar vehicle operation to higher performance standards. The expansion is also into a new realm of interaction between aeronautical and other engineering fields, especially as the flying device becomes merely one part of a complex and highly integrated apparatus system.

Systems engineering – the invention, the design, and the integration of the whole ensemble, as distinct from the invention and design of the parts – is an old and always present part of practical engineering. But the term "systems engineering" has become in recent years virtually a new one because the engineering systems with which we are now concerned are so much larger, more complex and difficult to engineer. This is partially because today our desire is to take huge steps in the technology rapidly. A typical, new, large engineering system depends much more than was the custom in the past on immediate exploitation of the newest discoveries in pure science. Furthermore, the relationship between the engineering and economic, military and even sociologic considerations, have become increasingly important. In these times, in which technology is altering our world so rapidly and in which government and industry must continually adjust to these changes, systems engineering has accordingly become a topic of almost semipopular interest.

Strangely enough, this enormous interest in systems engineering has not provided us with a flood of scientific articles that help us to understand what systems engineering is and how it is to be improved. Since very few write about systems engineering as a field of engineering discipline, and very few teach it despite the tremendous interest in it, it is tempting to conclude that one of two things must be true: (a) systems engineering as a technical discipline is too obvious to require elucidation, or (b) it is too difficult to explain. I shall rise to the challenge of the flattery of the invitation to deliver this lecture by electing to assume that it is a difficult and not an obvious field. By making such an assumption and by calling that assumption to your attention, I can be completely at ease for the remainder of this lecture because, if I do make some aspects of systems engineering clearer, you will presumably be pleasantly impressed and, if I do not add very much to your understanding of systems engineering, you will be generous enough to assume, I am certain, that it is because the subject is merely too difficult to make possible such clarity.

Probably no better example of the many interesting aspects of systems engineering can be found than guided missile systems. It seems then that to treat the advanced technology represented by the guided missile, with emphasis on the systems engineering problem, would provide us with a good opportunity to learn more about both.

This lecture will consist basically of three parts. In the first, we shall discuss systems engineering rather broadly. What are the common characteristics of complex engineering systems? What are the factors that usually must play a large part in system invention and design?

In the second part of the lecture, we shall add particulars in our exploration of systems engineering by reference to the guided missile art. Here we shall also have an opportunity to better understand guided missile systems.

Finally, with the general discussion behind us of what systems engineering is, and with guided missile examples

†The W. Rupert Turnbull Lecture for 1956 read at the I.A.S./C.A.I. International Meeting in Toronto on the 26th November, 1956.

*Executive Vice-President.

to make more specific these general impressions, we are ready to discuss how we can improve our ability to invent and design engineering systems.

Shortly, I shall complain that systems engineering needs to be more quantitative and precise. It can be a very mathematical subject if dealt with on a case-study basis. Yet this lecture is concerned entirely with qualitative considerations. This is not only because a good case-study approach would be handicapped by security regulations; it is also because I have felt it more important to give wide coverage to the subject, in view of the little that is written about it, even if each item must be dealt with only lightly.

THE GENERAL CHARACTERISTICS OF SYSTEMS ENGINEERING

Any device, no matter how simple — a nail, a chair or a hand tool — represents to its supervisory design-integrator a systems engineering problem. There is always the breaking down of the over-all problem into component subsystems and specifying the requirements on these parts. Always the problem exists of relating the parts to the whole and the whole to the outside world that originated the requirements and that expects a compatible answer. However, systems engineering becomes more interesting and its problems newer and more important to us as the scope of the complex engineering equipment grows. In discussing the general characteristics of systems engineering, we shall most often profit by assuming that it is the larger and more complex system that is under consideration, because this will magnify and make easier the calling out of its important characteristics. We must, then, acknowledge from the beginning that the broadest type of question will arise and require consideration.

Should the new system be created?

Perhaps the most basic question of all is whether the engineering systems should be created in the first place. To many engineers, the full impact of the need for going into such a question takes a very long time to register. The average engineering situation is one in which the engineer is asked to meet largely technical requirements. Of course, generally, he is aware of the economic constraints on his problem. For instance, he may be asked to estimate the cost of meeting the requirement and the time it will take. But there is something broader than this in the large systems job. If the job is big enough, then there are consequences associated with introducing the new system, such as interrelationships with the existing weapons if it is a military job, or the existing commercial operations of our economy if it is nonmilitary. Oftentimes, as a first approximation, it is known at the start that the so-called requirements are only a goal and will not be met with any total engineering system that may be designed. The broad objectives of any plan must be compared with the consequences. The systems engineering job requires first of all finding out what the job is to be and if indeed it should be attempted at all.

Let us anticipate our later discussion a bit concerning guided missiles in particular, whether they be used for military purposes or as pilotless commercial freight-carrying vehicles. Granted that the task must be done, the question will remain: should it be done with guided missiles?

The arrangement-making problem

When a systems engineering job is large enough, the financing of the project, the interactions with associated or displaced existing equipment and existing organizations that must operate or implement it, and the use of large quantities of technical and physical resources, can all be sufficiently consequential so that the mere arrangement-making problem of bringing off the whole system to final operation can become an important parameter in the overall systems engineering task. In other words, in deciding what to do, one must be sure to choose something that can be done. Feasibility of a specific large engineering system is not alone a matter of technical feasibility. We need to ask simultaneously whether arrangements to do the job can really be made.

Too many parameters

It is easy to go from these few remarks to a general statement that systems engineering in the large oftentimes has too many parameters. When the number of parameters that must be considered in any problem becomes sufficiently large, it begins to be impractical to be quantitative and precise. There is a tendency then to carry out the engineering of large systems with loose thinking or, at best, with purely qualitative methodology, rather than scientific and quantitative techniques. In such instances, systems engineering in the large becomes a matter of "opinion," as with religion and politics. In practice, what often happens is that some of the parameters are chosen arbitrarily. Of course, the moment that this is done, there is the risk that accidents and bias will control, for sometimes the parameters that have been chosen arbitrarily are in the end the most important.

The technical requirements

Even if we now limit our discussion for the moment to the more technical aspects of the over-all systems engineering problem, we can still retain most of the assertions heretofore made. We still have too many parameters in a large systems engineering problem to be as precise and quantitative as we would like. The tendency still exists to treat some parameters arbitrarily, with looseness and bias entering the picture. There is still the need, even within the limited part of the problem that can be called highly technical, for many technical specialists to attack the various phases of the whole and arrange somehow to integrate these into a compatible ensemble.

The technical problems in modern systems engineering are aggravated by the growing degree to which the very latest state of the art in both physics and engineering forms the basis for the systems engineering solution. If we seriously mean to exploit the very latest scientific advances, then we must have on the team individuals who fully understand these latest discoveries.

As soon as we endeavor to deal with a large number of parameters, then, of course, the theory becomes very complex. In most respects, trying to understand the workings of a complex engineering system in a quantitative sense is the same as trying to understand any other substantial segment of our universe. We must try to write the system's laws of behavior. We must devise

experiments that will test our understanding of its laws. Sometimes, such testing involves the invention of an experimental approach of a unique nature, a controlled experiment in any case. The kinds of individuals capable of predicting the action of such a complex multi-parameter system are very much the same as those who can pursue further our basic understandings of the laws of nature.

But if it is true that modern systems engineering in the large rests heavily on a scientific base, it is equally true that systems engineering also depends on the use of every tried and true engineering principle. A typical, complex engineering system includes countless pieces of equipment that are "on-the-shelf" items. The integration of these components and subsystems, and the practical reduction to practice of the whole, requires the most experienced practical engineers.

This acquaintanceship with the state of the engineering art is stretched to the utmost in modern systems engineering. In general, a desirable system, even when it has been ascertained that it is theoretically possible and not in violation of any known law of nature, and when a decision has been made to use wherever possible every "on-the-shelf" item, still calls for the design and creation of new components never before required but now needed to complete its workings.

Matching requirements to state of the art

Systems engineering in modern complex technology requires an unusual degree of matching of the requirements and the end objectives with the state of the technical art. As an example, we know that technically we can send freight around the world by guided missiles. What, however, is the true requirement for freight transport? What does the combination of scientific, economic and other factors say we should do? The problem of systems engineering starts with trying to find out what the problem is and could end by eliminating it as one that requires no solution, deserves no solution, or is impossible of solution with today's technical art.

The human subsystem

A modern system generally involves machines and men. It is becoming increasingly difficult to isolate these two parts of the total system and to deal with them independently and separately as though the other part did not exist. We must, in other words, think of the human being or a collection of human beings in a system as major subsystems or components. As best we can, we must introduce their characteristics into the over-all system's synthesis and analysis.

Probability concepts

Mention of the human element as a system component makes it easier now to call out another important characteristic of large complex systems — a characteristic that exists whenever the number of parameters or the number of system components is large, but which is increased in severity with the addition of human beings to the operation. We refer to the matter of statistical approaches and the specifying and testing of the system in terms of probabilities. In a way, this really expresses our inability to describe and design the system and measure its operation with precision. We must be satisfied with some impressions of how the system "probably" behaves. Probabilities are used to describe the various conditions presented to the system and we can only describe what it will do in response in terms of probabilities. The system is never perfect. It has errors and tolerances in its own internal operations and in its response to external inputs. Yet the problem of the systems engineer is somehow to learn to describe and measure the system characteristics by statistical methods so as to give the necessary desired probability of satisfactory operation.

Unwanted modes, instability

The systems engineer is not only plagued by the multitude of parameters, the indefiniteness of some of them, or the need for accepting and learning to live with probability as a way of thought in analyzing and understanding his systems. He must also recognize that, besides those characteristics which he has so carefully and purposefully built in and which he can predict in a satisfactory way, the system may have some possibilities of operation which he has not predicted and which he does not desire. For example, the system may be unstable. The more parameters a system has, the more possibilities there are for its modes of operation. I have used here the word "stability" to connote this potentiality of a system to operate in an unwanted mode. But, of course, stability is an inadequate and almost unsuitable term. If the system, indeed, is one that can be said to have a steady state, then undesired transients must attenuate so rapidly that the steady-state operation will not be unduly disturbed. That this is an inadequate way to describe our difficulty, however, is readily appreciated if one just considers that the whole desired system operation might be one best considered a transient condition, with the words "steady-state" hardly applying.

Simulators and computing machines

Analyses of complex systems, especially in view of the number of parameters and the probability considerations, are difficult and almost impossible without large computing machine aids. No systems engineering team is complete, up-to-date, or even remotely skillful in systems engineering unless it includes team members who are skillful in the use of these machines. Dependence on large-scale simulation for testing is as important as the use of machines for analysis. It is usually difficult, if not impossible, to conduct sensible experimental operations exclusively on the final assembly of equipment that constitutes the complete system.

GUIDED MISSILE SYSTEMS—THE MISSILE PROPER

Let us commence our more detailed discussion of the systems engineering problems involved in guided missile systems by separating the discussion into two phases. First, let us look at the guided missile proper — the vehicle with its internal equipment, which is the one part of the total system which leaves the ground and most often is expected to return to it, and which is only a small part, although often the most superficially conspicuous one, in the whole missile system operation. We shall try for a while to overlook the fact that this one subsystem element must be related to a much more complex over-all problem. Then, after looking at some of the detailed systems interactions involved in this missile proper, we

shall expand our sights to include the entire guided missile system. We can call the first part of the discussion, then, that of the guided missile system in the small, and perhaps the "internal" as against the "external" systems engineering, and as against guided missile systems engineering in the large.

Alternate approaches

Our first problem is facing up to the fact that in all probability this missile is itself a complex large systems problem and that it has enough parameters and flexibility for what it must do and how it must do it so that alternate approaches will have to be considered and compared. Experience indicates that it is not always easy for a group of engineers (since systems engineering is not a sufficiently developed art as yet) to face up to this systems engineering problem. The temptation is all too great for the engineering team to be dominated by a few initial ideas or inventions by some of the team members. This arbitrary choice of some of the more important parameters, while perhaps a necessary beginning point, can, with an inexperienced or untalented systems engineering team, come too close to being the end point, with the rest of the exercise being used to justify, defend, or somehow make work the favored and specific ideas brought into the picture at an early stage. How is the missile to be propelled and guided? How will these subsystems be physically arranged? What will be the dominant line of thought intended to get around what appears at the outset to be the one or two overriding difficulties that are anticipated as limiting the performance possibilities? Here again the engineering team must be careful not to choose a power plant, or a technique of guidance, only because it was invented by that team or because a part is in production in the factory with which they are directly related. These are important reasons for the serious consideration of the use of these components, but they are not good enough reasons for failure to consider other approaches in the original comparison of alternate approaches. The need for such open-mindedness may appear to be obvious, but in complex and difficult design problems with too many parameters it is all too easy for human beings to be led into an approach that is nearer to "closed-mindedness" than open-mindedness and objectivity. It is true that usually there is a need for limiting the broad studies because of urgency or by a host of practical factors, of which the existence of an item on the shelf is but one. In other words, with strong reasons existing for intuitive and judgment selection from many parameters and for fast action to eliminate endless investigations of alternate approaches, it requires an experienced systems engineer to insure the proper width of the opening of the mind.

Some old problems

Guided missile systems engineering includes some old problems which do not require further elucidation. Many of these problems have to do with physical integration of the various components into a mechanically consistent over-all structural package. Electrical interconnections and communications from one end of the missile to the other also are in this category. Of course, a great many of the physical integration and internal systems engineering problems of a guided missile are no different from those of an airplane. The novice is amazed to discover the tremendous number of wires required to make an airplane work, in addition to the nuts and bolts, fasteners, supporting fixtures, doors, openings and the like, but their quantity is routine knowledge to many engineers experienced in these matters. These same important, if mundane, systems problems exist, of course, in the guided missile.

Also, we can cover merely by mention a class of guided missile problems, again virtually identical to the airplane problem, that dominate when the guided missile is a relatively simple subsonic airplane equipped with an autopilot and a radio receiver to pick up some instructions from the ground and provide an output signal into the autopilot, especially if the guided missile is asked to do something very similar to what a manned airplane does at subsonic speeds.

Guided missiles with humans aboard

Nevertheless, much of what will be said in this lecture applies to some situations, both military and civilian, in which moving vehicles have humans as passengers and pilots. When much automatic operation exists, both in the vehicle itself and in the vehicle's relationship to the ground and other vehicles, then to a first approximation we have a guided missile; the pilot may aid and influence the performance of the system, but most of the problems of a guided missile have to be considered by the systems engineer. In some ways, of course, a guided missile with a man aboard is a more complex system, especially if we expect the man to participate in the operation of the system and not just go along for the ride. But even if he is no more than a passenger and observer, we have the additional parameters of making possible his remaining alive and useful during the entire operation.

High speed problems

A typical guided missile as a vehicle containing a great deal of equipment has its own set of problems, however; some of these constitute merely an aggravation of the problems present in the ordinary subsonic military or civilian airplane. One of the key factors complicating the typical guided missile is its speed. The considerations that lead one to omitting the man and incorporating synthetic intelligence most always carry with them the requirement for speeds well beyond those of the airplane.

Propulsion integration

From the systems standpoint, the high speeds bring in a number of interaction problems that require an unusually close association amongst the supersonic aerodynamicists and the other specialists who make up the systems engineering team. For one thing, the integration of propulsion with the airframe represents a greater systems problem for a very high-speed moving vehicle than for a low-speed one. At low speed it is easier to separate the propulsion and the airframe problems and to do a considerable amount of independent designing before merging the two. As the speed increases, such isolation is generally more difficult and less realistic. In guided missile work it often becomes virtually an absurdity to try to separate the propulsion from the aerodynamics. This is particularly true if the propulsion is provided by ram-jet or essentially a hole in the struc-

ture, or if the missile's other components are dwarfed in size by the engine and fuel tank. Largely because of the speed ranges in which guided missiles operate, the propulsion techniques applying to them are newer, not so well understood, and impose more flight-test difficulties than those in conventional lower-speed propulsion devices, thereby making more difficult their integration with the airframe.

High accelerations

Attainment of high speeds implies, of course, either higher accelerations than the preguided-missile art typically uses or else long periods in which the velocity changes are significant. Large variations in velocity and the direct environmental effects of acceleration complicate the whole systems engineering job. Unusual acceleration requirements influence the reaction of equipment to the high acceleration, the need for measuring in order to control the acceleration, the problems of fuel-pumping and the problems of the entire structural design. In general, high acceleration must be anticipated in a quantitative sense. Alternate approaches can be rejected or accepted partially on the basis of what the peak acceleration is, or what the average acceleration is. Trajectories, guidance accuracies, range, total weights and physical arrangements are all functions of the acceleration. Moreover, the acceleration itself is a function of these very parameters, since it is not possible to be assured of a specific acceleration unless we can either arrange to measure such acceleration and force it on the system by control of the propulsion and other parameters, or predict the weights and thrusts and other forces sufficiently for the entire flight in order to know what the acceleration will be.

Heat transfer and temperature

Some important systems problems stem from heat transfer and temperature considerations. Basically, of course, we are concerned with the heat balance and the heat transfer because we want to insure proper temperatures throughout the entire vehicle. The range of possibilities and the interactions reach an interesting new high in guided missiles compared with most physical apparatus with which the engineer has to deal. As one example, we can obtain such velocities by proper arrangements of propulsion systems and structures so as to insure destruction of the entire vehicle from aerodynamic heating alone. As another example, some propulsion systems associated with guided missiles use liquid gases for propellants. Consider, also, the fact that the temperature of the external environment inhabited by missiles can vary with the highs and lows of the space and the atmosphere about the earth. To make matters worse, in guided missiles we cannot be generous about space and weight in order to provide insulating and temperature control chambers at will.

In general, there are alternate paths for a missile to travel. One of the factors that determines the trajectory is the heat generation problem. Heat generation is a function of the time spent and the velocity reached by the missile in the various portions of the atmosphere, as well as the air temperature and density, which again vary with altitude and hence trajectory choice. Trajectory choice in turn influences guidance, control and propulsion problems.

Control of the missile

Control is almost by definition a systems problem, because it most certainly involves a close relationship among the aerodynamics forces, the propulsion thrust forces and the mass distribution and inertia of the vehicle itself, to which we add motion and direction-sensing devices and special components for producing alterations in the applied forces to insure controlled flight. In a typical guided missile situation, these systems problems are aggravated by the following factors, to mention only a few examples. One is the speed range. In a guided missile, the speed may range from zero (or even negative) to satellite velocities (or higher). It is certainly a complicating factor in designing a control system to handle the problem of continually-varying main parameters. But we cannot attain a wide speed range and still have the vehicle remain a constant in total weight and applied forces. As a matter of fact, multistage vehicles must often be included in our considerations. Here part of the missile suddenly departs during the operation, with a sudden change of control parameters. It is not true in general that the propulsion forces can remain constant, because it will be desirable, if not necessary, to switch propulsion systems on and off, or at least to accept variations in thrust owing to the relationship between the thrust-producing mechanisms and the varying atmospheric pressure. High velocities and high ranges of velocities suggest that relatively large fractions of the total missile weight will be made up of fuel which, by being rapidly exhausted, will radically alter the weight of the missile during flight.

The missile may range from operating in thick air to no air at all, with aerodynamic forces changing from important to trivial. Not only can the parameters alter during the course of the flight, but these parameters can in some instances alter so rapidly that the time of sensing, processing and acting on the information to alter the missile's flight can be comparable to a substantial change in control system operating parameters.

Stability in the usual sense may not exist without the inclusion of a fairly complex control system. It is common to assume that a design goal for a vehicle is that, in the absence of desire to turn it, it will fly in a stable manner. That is, if for one reason or another it is disturbed in its flight, such disturbance will die out rather than build up. In a typical guided missile, the other problems of speed range, provisions for high turning rates and for response to guidance system orders, the problem of physical integration of the components in relation to one another, and the problems of changing or shifting mass and center of pressure — all these may force a design which simply cannot be made to have this kind of simple natural stability. A disturbance will build up unless, in effect, it is neutralized by special automatic action of a fairly complex control system, including sensing instruments to determine that instability has set in and the means for applying the right counter forces. It is apparent that with the ranges that might be covered by that missile, both as to atmospheric conditions and over-all performance requirements, aerodynamic forces alone may well be insufficient to provide the stabilizing forces. One must either resort to thrust control or to a combination of aerodynamic and thrust control.

Supervisory guidance

Use of the word "control" so far is meant only to imply the ability of the missile to fly on the intended path. The determination of the proper intention as to what the control system should seek to bring into effect will be described better by the words "precision guidance" or "supervisory guidance". The missile may be guided by signals coming externally or by signals that result from observations made by the missile itself, or by a combination of these. In any case, there are certain aspects of the existence of this guidance problem that influence and add to the systems engineering problem of the missile proper. We shall next enumerate some of these.

Man's ability to position or direct an object in flight is a function of many parameters – the precision of the initial conditions, the precision with which we can control the forces that act from that point on and the over-all precision of measurement of the entire operation. In a given missile situation, the phenomena brought into play go well outside the missile proper. We must insure that the missile is so designed that it can accept signals with precision and can act on these signals with corresponding or matched precision. In the first category, let us assume that the signals originate at least partially from the outside by way of electromagnetic energy reaching the missile, or by way of the missile's originating signals for the purpose of examining for itself its surroundings and receiving back some response to its investigation from the outside. In any case, the missile must be designed with proper windows, antennas, holes, or, broadly speaking, "connections" with the outside world for measurement purposes. The problem may involve the missile's being a good reflector for radar so that it is a proper partner in the guidance operation which may include radar stations elsewhere in the system. The form, size and material of a missile's structure are accordingly potential participants in the guidance subsystem.

A specific trajectory chosen by the missile may include the necessity for catering to the guidance subsystem. In some applications the missile is more or less easily seen or communicated with by other parts of the system as a function of the trajectory chosen. Perhaps the missile's allowed orientation deviations will be a function of the nature of and the location of the precision guidance elements in the system. The shortest distance between two points that are stationary, and the simplest path, may be a straight line, but since the problem is ordinarily more complex than that, the path required is generally a curved one when optimized. Accordingly, corrections which the precision guidance calls for during the flight may be considered to be oftentimes superimposed upon the average bias or settings required of the control system.

If the missile flies in such a way and has such a physical over-all design that it can cooperate properly with the rest of the system in receiving or transmitting signals that are part of the guidance loop, it must further be designed to be consistent with the part that its own interior equipment may play in the generation of guidance signals. In general, in order that the instrumentation on board the missile will operate properly as a participant in guidance signal generation, great attention must be placed on the matter of environmental conditions. The acceleration, vibration and temperature conditions of a missile have an important bearing on the ability of the missile to be a participant in the generation of guidance system signals.

It will not do to determine with precision what we want the missile to do, only to find that the missile is unable to respond. This matching of capabilities to requests shows up in many ways. Firstly, there is the question of magnitudes. The turning capability for changing of direction and the acceleration and deceleration for changing of magnitude of velocity must, of course, be built into the system; but the guidance system, in addition to calling for specific magnitudes of changes, may also require such changes in too short a time. We have, then, not only the change magnitude that may be requested, but the rate of change of magnitude requested. Sometimes it is more convenient to think in terms of a spectrum, with an amplitude-frequency distribution of possible guidance requests. Now, in any case, the missile has time delays. The putting together of these factors on a realistic basis really means, among other things, that the missile's physical ability to respond becomes part of the over-all guidance design. Precision guidance must always involve the recognition that decision making cannot be done with absolute perfection. The data are never perfectly clear and the processing of the data by the guidance system is less than perfect. Misinformation is mixed with information; there is always noise on the signal. Every instrument reading, every radar observation, every gear in the system has errors, slippage, backlash and noise. The guidance system must be based on a recognition of these phenomena and, as a result, the best decision as regards the change in motion to be requested of a missile requires time for automatic contemplation of the entire situation. If too long a time is taken to deliberate, the performance will be less than optimum. The target may be missed, more fuel may be expended, or more accidents may occur because the decision may be out of date by the time it is made and the guidance may come too late to affect the missile's flight. On the other hand, it is equally true that if the decision is made too rapidly, we will be on the other side of optimum. Accordingly, then, precision guidance considerations involve matching the time constants and the precision of control of thrust and missile dynamics with the other considerations of guidance.

The tightness of physical integration

With these additional points concerning control, trajectories and precision guidance now established, we can more easily add now some special emphasis on the tightness of physical integration. In an airplane we have typically a great deal of electronics equipment and electromechanical auxiliaries, but we are able to think more in terms of buying individual boxes that are physically quite separate from the rest of the structure. In a typical guided missile, the tightness is, on the average, an order of magnitude or two orders of magnitude greater. The pumping of fuel and the whole physical arrangement of the details of the propulsion system are

tied in with the special shape of structure and the accelerations, pitching and rolling, that are dependent so much on the guidance and control system.

In anything that flies, it is common enough to be concerned about total weight and weight distribution. In a missile, this concern in general increases because all of these effects increase so rapidly with speed. We are sensitive to vibration in all powered devices and, particularly, in devices that fly through the sky. The understanding and control of mechanical forces over a wide spectrum (call it vibration, or call it thrust and acceleration control) is very much greater because of the relationship that exists amongst the instrumentation involved in precision guidance, where a small fraction of one percent in velocity or acceleration control may be important.

One must be careful about the positioning of an antenna on an airplane, but a substantial fraction of the entire form and surface of a missile may be taken up with a radome, which constitutes a shape and strength problem and also a problem of electromagnetic wave transfer. Precision as well as magnitude is involved, since the tapering and shaping have a direct effect on the ability of the missile to either make observations or receive information from the outside with the necessary accuracy. It is difficult enough to design a body to provide that, from the aerodynamics standpoint, consideration is given to such factors as aerodynamic interference and turbulence. But this is complicated by the need for choosing the shape and material so as to satisfy precision electromagnetic wave transmission requirements as well.

Transient versus steady-state

To continue our discussion of internal systems engineering, we need next to dwell for a while on one common characteristic of guided missile systems — namely, the fact that the entire guided missile operation is often best considered as a short transient rather than a steady-state operation.

If a missile is to fly for a long time at a more or less constant altitude, like an ordinary airliner on a long distance flight, much of what has to be done in the detailed systems engineering of the missile can be done with an underlying philosophy that there is a steady-state performance, complicated only by some take-off and landing phases during which time conditions change rapidly. In other situations, however, there is very little that can be accomplished by using the idea of a steady-state situation as a basis, because it appears that from the beginning to the end of the guided missile's flight a succession of rapidly changing conditions is involved, for example, an air-to-air missile or a ballistic missile.

For most of the time, in a ballistic missile flight of thousands of miles, very little happens; just a free fall in empty space. During the portion of the flight from the launch to the attainment of final velocity, and from the time that the delivery stage re-enters the atmosphere, all of the systems engineering problems are encountered. It is with these phases in mind that we should consider the design from the standpoint of being a transient throughout, rather than a temporary end effect which is merely a complication on a steady-state. First of all, for a ballistic payload to travel thousands of miles, the attainment of velocities of some tens of thousands of feet per second is necessary. If this velocity is to be obtained in a few minutes, say a few hundred seconds, we must accumulate on the order of one hundred feet per second velocity in every second of powered flight. A large device, such as one which would be required to carry all of the fuel and auxiliaries and structure necessary to bring a substantial payload up to such high velocities, will naturally have such inertia that the response of the whole device to directions will require of the order of seconds. In other words, the response time is as long as the time it takes for a substantial change to occur in the parameters of the system. The analysis of what happens and the understanding of the behavior of such a system should be done quantitatively on a real time, transient basis, starting with the beginning of flight and allowing all of the factors to play against one another in arriving step by step at the final velocity.

A way in which this concentration on transient behavior brings up some new problems is exemplified by the concept of stability, mentioned earlier. If the transient is small enough in time duration — that is, if the entire flight is short enough — we can tolerate what might otherwise be considered an instability. We are not concerned with the fact that an undesired oscillation is building up in the system and threatens to eventually saturate all of the controls and thereby ruin the mission. We need be interested only if this undesired effect builds up sufficiently during the short transient life of that phase of the missile's operation that it reaches an interfering magnitude. Nor is it necessarily forbidden for the missile's trajectory to possess wiggles, so long as it still hits the target.

Let us return for a moment to the guidance example for another aspect of the singular transient domination of guided missile design considerations. Here one of the main factors is the need for outshouting the noise — the separating of the wheat from the chaff, the finding of the best guess as to what the facts are in the combination of good and bad information available to the guidance system. Ordinarily, in information processing, the conventional methods make the assumption of a steady-state. Given some incoming messages and a recognition that some noise accompanies them, one can take time to deliberate and arrive at the best conclusion. In the guided missile situation, not only are changes taking place rapidly while this processing goes on, but the very base of assumptions around which this deliberation is made alters. For example, suppose we are homing on an airborne scintillating target which provides us with a radar echo. As we close on that target, the signal energy builds up rapidly and the relationship between signal and noise changes even while we are trying to separate one from the other.

(To be continued in the next issue)

A METHOD OF PREDICTING THE AIRBORNE PART OF THE TAKE-OFF DISTANCE OF AN AIRCRAFT†

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SUMMARY

The airborne part of the take-off distance of an aircraft depends primarily on the piloting technique which gives rise to the normal acceleration of the aircraft during the transition manoeuvre. An empirical formula for the piloting technique, developed from the quantitative analysis of the take-off tests of two aircraft, is given here with its physical interpretations. The method given in this note will enable one to predict with reasonable accuracy the minimum practicable (not necessarily the minimum possible) airborne distance for a particular value of unstick speed to power-on stalling speed ratio.

Airborne distance thus obtained must be regarded as the minimum practicable distance. A suggested modification to the piloting technique, with which the airborne distance under normal (civil) technique can be estimated, is also given.

INTRODUCTION

It is a well established fact that the airborne part of the take-off distance of an aircraft depends primarily on the piloting technique. The major uncertainty in the analysis of the test results and in the prediction of the airborne distance, therefore, lies in the assumptions that have to be made regarding the piloting technique during this part.

The second major factor affecting the airborne distance is a wind gradient that is likely to be present during the tests. A treatment of this effect, along with the derivations of some fundamental formulae used in such an analysis, is given in Reference 1.

The purpose of this note is to state with physical interpretations an empirical formula for the piloting technique and show its application in predicting the airborne part of the take-off distance of an aircraft.

SYMBOLS

e	2.7183
g	gravitational acceleration (ft/sec^2)
h	height of the aircraft above ground (ft)
m	constant
n	normal acceleration experienced by the aircraft during transition after unstick
w	wind speed (head wind positive) (ft/sec)
A	constant
D	total drag of the aircraft (lb)
K	ratio of unstick speed to power-on stalling speed, V_{1_0}/V_S
K_1	ratio of unstick speed to power-off stalling (or minimum control) speed, V_{1_0}/V_{S_1}
S	wing area (gross) (sq ft)
S_{A_0}	airborne distance in zero wind (ft)
S_{g_0}	ground run in zero wind (ft)
T	total net thrust of the power plant (lb)
V_0	true airspeed of the aircraft (ft/sec)
V_{ave}	average true airspeed of the aircraft between unstick and 50 ft height (ft/sec)
V_S	power-on stalling (or minimum control) speed of the aircraft (ft/sec)
V_{S_1}	power-off stalling speed of the aircraft (ft/sec)
W	weight of the aircraft (lb)
γ	longitudinal acceleration of the aircraft, $\frac{T-D}{W}$

Subscripts

1	conditions at or near unstick
2	conditions at 50 ft height above take-off surface —

thus V_{1_0} and V_{2_0} are the true airspeeds of the aircraft in still air at unstick and at 50 ft height respectively.

LEADING ASSUMPTIONS

(1) The flight path of an aircraft from unstick to the 50 ft height is a circular arc, that is, the whole airborne distance from unstick to the 50 ft height is a transition distance.

(2) The wind structure near the ground can be presented by a law of the following nature[1].

$$\frac{w}{w_1} = \left(\frac{h}{h_1}\right)^{\frac{1}{m}}$$

where h_1 is the known height (usually the height of wing of the aircraft) above ground at which wind velocity, w_1, is known or measured.

m = constant = 7 is assumed in the numerical calculations (Reference 1).

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PILOTING TECHNIQUE OR PILOT'S RESPONSE DURING TRANSITION

The pilot's response or pull on the stick during transition after unstick results in the normal acceleration of the aircraft. This response or pull is influenced by the airspeed of the aircraft during transition. The airspeed, in its turn, depends on the longitudinal acceleration of the aircraft and the wind gradient[1]. The pilot will and does exert harder pull if he sees the airspeed of the aircraft after unstick rising very rapidly above the unstick value. In order to obtain the minimum practicable airborne distance, the pilot will try to hold the airspeed during transition at or near the unstick speed value. Harder pull on the stick than that required to hold the airspeed at or near the unstick speed value will result in an airspeed at the 50 ft height lower than that of the unstick speed with a danger of inadvertent stalling. In other words, the pilot's response or pull (normal acceleration of the aircraft) during transition after unstick will, no doubt, be influenced by the airspeed — hence by the longitudinal acceleration of the aircraft, as well as wind gradient; at the same time the pilot's response will be cautioned by the safety margin of the unstick speed over the power-on stalling speed of the aircraft. This is the fundamental basis behind the following empirical law for the piloting technique.

Pilot's response (normal acceleration of the aircraft) during transition after unstick in zero wind is given by,

$$n = 1 + (K^2 - 1)\,e^{-\frac{A}{\gamma}} \qquad (1)$$

where A is constant.

An analysis of the take-off tests of two aircraft showed that constant A in Eq. (1) has values between 0.07 and 0.09. Using Eq. (1) with $A = 0.07$, the take-off tests of the De Havilland Beaver were analyzed under assumptions (1) and (2) mentioned above and the calculated values of the airborne distance are compared with the measured values in Figure 1. It can be seen from Figure 1 that about 78 per cent of the calculated values are within 10 per cent of the test values.

PREDICTION OF THE MINIMUM PRACTICABLE AIRBORNE DISTANCE IN ZERO WIND CONDITIONS

Using $A = 0.07$, Eq. (1) becomes,

$$n = 1 + (K^2 - 1)\,e^{-\frac{0.07}{\gamma}} \qquad (2)$$

By writing down the equation of motion of an aircraft along the flight path during transition after unstick, under assumption (1) mentioned above, and by a little mathematical manipulation, the equations for the airspeed of the aircraft at the 50 ft height and for the transition distance from unstick to the 50 ft height above the take-off surface are obtained. (Derivations of the equations are given in Reference 1.)

$$V_{2_0}{}^2 = V_{1_0}{}^2 + 2V_{1_0}\gamma\sqrt{\frac{2gh}{n-1}} - 2gh \qquad (3)$$

or

$$V_{2_0} \approx V_{1_0} + \gamma\sqrt{\frac{2gh}{n-1}} - \frac{gh}{V_{1_0}} \qquad (4)$$

$$\text{provided} \left[\frac{2\gamma\sqrt{\dfrac{2gh}{n-1}}}{V_{1_0}} - \frac{2gh}{V_{1_0}{}^2}\right] \ll 1.0$$

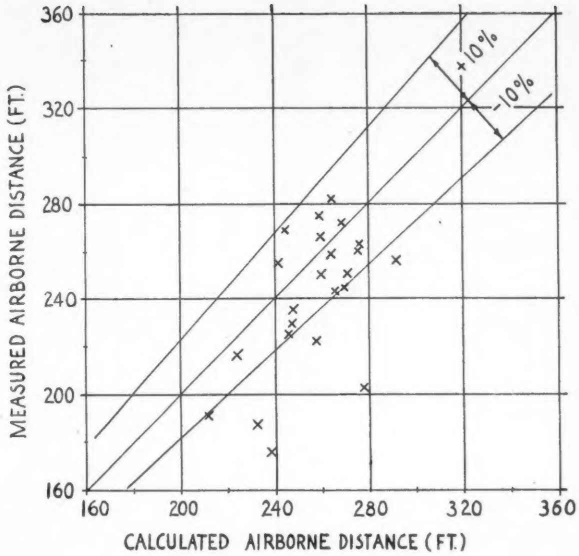

Figure 1
Comparison of calculated and test results of De Havilland Beaver

The airborne distance from unstick to 50 ft height is given by

$$S_{A_0} = \sqrt{\frac{2h\ V_{ave}{}^2}{g(n-1)} - h^2} \qquad (5)$$

V_{ave} in Eq. (5) is an average speed between unstick point and 50 ft height. For engineering purposes, this average speed can be taken as an arithmetic mean of the unstick speed (V_{1_0}) and the speed at the 50 ft height (V_{2_0}), the latter being evaluated by using either Eq. (3) or (4).

Listed below are the steps that can be followed in the prediction of the minimum practicable airborne part of the take-off distance of an aircraft in zero wind conditions.

For a particular value of K,

(1) Calculate $\gamma \left(= \frac{T-D}{W}\right)$ from the power plant and drag characteristics of the aircraft.

(2) Calculate n by using Eq. (2) and then the average value of airspeed between unstick and 50 ft height points, after having evaluated the speed at 50 ft height by using Eq. (3) or (4).

(3) Calculate airborne distance, S_{A_0}, by using Eq. (5).

It must be kept in mind that the airborne distance, which can be predicted by following the treatment described so far, must be regarded as the minimum practicable one, since the development of Eq. (2) is based on this particular technique. It must also be recognized that the technique for the minimum practicable airborne distance, such as developed in this note, will not give the minimum practicable total take-off distance (ground run plus airborne distance). Since the ground run increases roughly as the square of the unstick speed, the optimum value of K, for which the total take-off distance from the start of the ground run to the 50 ft height is minimum, can be determined by a graphical analysis, that is, by plotting the total take-off distance against K.

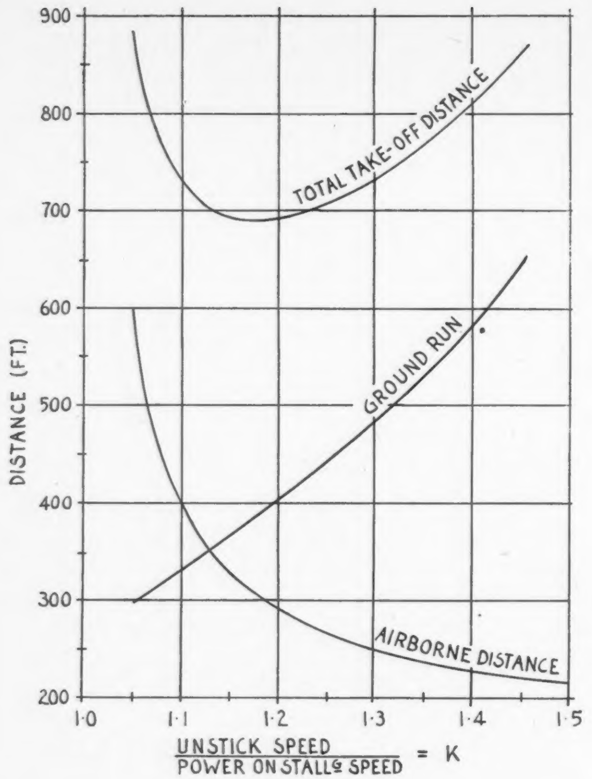

Figure 2
Determination of the optimum value of 'K' for minimum take-off distance

This case is illustrated in the Appendix and the results are shown in Figure 2.

PREDICTION OF THE AIRBORNE DISTANCE UNDER NORMAL (CIVIL) TECHNIQUE IN ZERO WIND CONDITIONS

The take-off technique in the case of a civil aircraft is restricted, to some extent, by the regulations of the Civil Airworthiness Authorities, so far as the unstick and the climb-away speeds are concerned. For example, for a twin-engined aircraft the unstick speed is required to be not less than 1.2 times the power-off stalling speed or 1.1 times the minimum control speed, while climb-away speed or the speed at the 50 ft height above the take-off surface is equal to or greater than the unstick speed value. Also, the thrust to weight ratio of a civil aircraft is, in general, not very high. For these reasons the pilot will be rather cautious to pull high "g" during the transition manoeuvre. The following two alternatives are suggested in the course of the modification to the piloting technique developed above to predict the airborne distance under normal (civil) technique.

(1) About half the value of $(n - 1)$ as calculated from Eq. (2) may be used, or

(2) n under normal (civil) technique may be evaluated by using the following formula.

$$n = 1 + (K_1^2 - 1)\, e^{-\frac{0.07}{\gamma}} \qquad (6)$$

where K_1 is a ratio of unstick speed to power-off stalling speed or minimum control speed.

CONCLUSIONS

It is believed that the method developed in this note will be useful in predicting the minimum practicable (not necessarily the minimum possible) airborne distance, as well as the airborne distance under normal (civil) technique.

This method of predicting the airborne distance can be combined with the method of estimating the ground run (as done in the Appendix) in order to predict the optimum value of K, for which the total take-off distance from the start of the ground run to the 50 ft height above the take-off surface is minimum.

REFERENCE

(1) Tamboli, R. B. – *The Effect of Wind Gradient on the Airborne Part of the Take-off Distance of an Aircraft*, D.H. Aero. Dept/1440/RBT/GEN (1955).

APPENDIX

ILLUSTRATIVE EXAMPLES

(A) It is intended to estimate, under I.S.A., sea level and zero wind conditions, the minimum practicable airborne distance for a twin-engined aircraft whose characteristics are given below.

Wing loading, $W/S = 22.6$ psf
Power on maximum lift coefficient = 3.10
Unstick speed = 1.2 times power-on stalling speed
$(V_{1_0}) = 94.1$ ft/sec, T.A.S.
$\therefore K = 1.2$
$\gamma = 0.26$
From Eq. (2), $(n-1) = 0.336$
From Eq. (3), speed at the 50 ft height
$V_{2_0} = 102.1$ ft/sec, T.A.S.
$\therefore V_{ave} = 98.1$ ft/sec, T.A.S.
From Eq. (5), minimum practicable airborne distance, $S_{A_0} = 293$ ft.

(B) It is intended to find the value of unstick speed (that is to find the value of K) at which the total take-off distance from the start of the ground run to the 50 ft height above the runway is minimum.

The aircraft used in this case is the same as in case (A) above. For different values of K the calculations were made for both the ground run and the minimum practicable airborne distance. The results are shown in Figure 2, from which it can be seen that the minimum total take-off distance occurs at a value of $K \approx 1.18$

Note: In the calculations of ground run the following formula was used.

Ground run,

$$S_{g_0} = \frac{V_{1_0}^2}{2g\left\{\frac{(T)_{0.7V_{1_0}}}{W} - \mu - (C_{D_g} - \mu C_{L_g})\frac{(q)_{0.7V_{1_0}}}{W/S}\right\}} \text{ (ft)}$$

where $(T)_{0.7V_{1_0}}$ = total net thrust of the powerplant at 70% of the unstick speed (lb)
$(q)_{0.7V_{1_0}}$ = dynamic pressure at 70% of the unstick speed (psf)
C_{D_g} = drag coefficient of the aircraft during ground run (ground effect included)
C_{L_g} = lift coefficient of the aircraft during ground run
μ = coefficient of rolling friction

SUPERSONIC PASSENGER-CARRYING AIRCRAFT†

by B. S. Shenstone*

British European Airways

It is useless to discuss whether we shall have supersonic airliners. We must assume that passenger-carrying air transports will fly supersonically. Let us not have any doubts about this. Let us not raise imaginary barriers where no barriers exist.

Ever since flying started, people have imagined barriers to operational speeds. Initially, they were simply barriers based on complete ignorance, such as the confusion of speed with acceleration. Later, barriers were based on less ignorance, such as in the early Thirties when it was argued before the Royal Aeronautical Society that cruising speeds higher than about 120 mph would be uneconomic. Considering that twenty years later we are cruising at about 400 mph and that in three years we are planning to cruise at nearly 600 mph and economically at that, it indicates how wrong one can be.

Only a short time ago, I myself thought that there would be several years of marking time at about 600 mph before we crossed the sonic barrier (which is now no barrier at all) and started to fly at about 750 mph. Newer developments have already shown that we should be able to fly at speeds very slightly above sonic speeds so that large steps forward may not be necessary.

In my opinion, the more one studies the problem of speed and the more knowledge one gathers, the higher are the speeds that one can foresee during the next twenty or thirty years.

It may be worth while to make special reference to Eugen Sänger's[a] recent prognostications based on many years' research and development on propulsion. He foresees that the rate of increase of air transport cruising speed will be considerably greater in future than it has been in the past. He bases this not on casual thinking, but on his knowledge of the state of development of the power plant. The faster one goes and the higher one flies, the more it becomes a matter of power plant rather than aerodynamics.

This may seem arguable considering the terrific aerodynamic troubles that are now being experienced, but once you get to very high altitudes of the order of fifteen to twenty miles, the shape of the vehicle has less and less significance aerodynamically and one can make the vehicle a convenient shape structurally with possibly auxiliary gadgets for landing and take-off.

Briefly, Sänger suggests that civil transports, by 1962, will be flying at sonic speed. In 1970 they should be flying at 2,500 mph, which is about as fast as a ramjet will take you. For the next step, in the 1980's, "escape speed", which is 25,000 mph or 7 miles per second, should be achieved, probably by atomic rocket. Sänger no doubt refers to prototypes flying at these speeds and if you add five years more, or even ten years, for production at sonic speed and ten years more for "escape speed", you still have a very marked speed increase over the next quarter century.

ECONOMICS

Whether at these very high speeds the operation will be more or less economic than at present, I do not know but my guess is that the next step forward to 750 mph will be sufficiently economic to push anything slower out of the running.

This guess is the crux of the whole problem and we must look at it critically. It may seem tiresome for economics to intrude upon interesting engineering matters, but in this problem the whole thing hangs on whether these supersonic aircraft can pay their way. Without designing one and pricing it, there can be no firm answer, but it is worth while discussing trends and the general shape of things.

It is always difficult to find a replacement for a given aircraft and one which is cheaper to operate. You may well wonder why, because our knowledge is steadily increasing and, as time goes on, we must be able to do better. That is correct. On the other hand, there are other influences at work, such as,

(1) We always want higher speeds for our new aircraft. To design a new faster aircraft and still remain as economical technically as the slower machine is difficult, but it can be done and is done.

(2) We are in a state of inflation so that the cost of new aircraft, even of the same design, is more than earlier batches. The cost per pound of newly-designed aircraft is much more.

†Paper read before the Montreal and Ottawa Branches of the C.A.I. on the 20th and 21st November 1956 respectively and the Vancouver and Winnipeg Branches on the 3rd and 5th December respectively.

*Chief Engineer.

[a]Luftfahrttechnik, July 1956, p. 131.

(3) The airlines' fare structures are not as inflationary as almost everything else. In fact, over the past ten years the price of air travel per mile has hardly changed at all.

How can we get higher speeds and fight inflation and keep the same fares?

The answer is tied up with traffic trends. Even in the U.S.A. and Australia, the two countries with the densest air traffic (as a proportion of the population), one can say that a great potential air traffic remains untouched. The only way to get it is to keep the fares down. The present trends are upwards but will not be accelerated unless the fares come down. If we must bring fares down and get in return a greatly increased traffic, we shall need either more or larger aircraft. Now it happens that the only way to bring flying costs down in view of the inflationary tendencies existing is to make the seating capacity greater. Hence new aircraft must be larger than their predecessors. One is immediately beset by fears; Will the traffic really increase enough? Will the costs actually decrease as promised? Of course there are no answers to either question. Nobody can really know about traffic. As to costs, the present rate of inflation indicates that it is just about possible, by making the new aircraft about 80% to 100% larger, to keep the actual costs about level. On paper, this means that the new type when conceived should show about 10% less cost. When it is in service, inflation will have caught up.

So perhaps even much more than 100 seats for a supersonic airliner is not enough. After all, in these guesses I have not taken into account the great increase in power necessary to increase speed from 600 mph to 750 mph. We may well find that no matter what we do regarding refined aerodynamic and structural techniques, the operation of the supersonic transport may be more costly per seat-mile than can be covered by existing fare patterns. On the other hand, new knowledge may show me to have been pessimistic.

I think it is unwise to prophesy much more at this stage, when in fact we are not yet flying passengers supersonically, but it is worth pointing out that some people's prophecies go far beyond the "escape" speed for the carriage of passengers towards the end of our century. However, all this will be a difficult, hazardous and expensive process and today we must concentrate on the immediate problems and stop right now being fanciful.

THE MACH 1.15 AIRLINER

Our first real problem is a strictly practical one. It is to draw up a requirement for an aeroplane cruising at something like 750 mph. We have to decide very soon fundamental things about this, such as runway length required, minimum and maximum ranges and practicable flying altitudes. On such an aeroplane, which would be cruising at a Mach number of about 1.15 at altitude, there are peculiar operational techniques to be developed. The climbing speed of this aircraft would be considerably subsonic and it would probably pass through the sonic range at something like 30,000 ft. At an altitude of about 35,000 ft, this Mach number of 1.15 would indicate a cruising speed of 760 mph, but if operations demanded under special conditions an altitude of, say, 20,000 ft, the aircraft would have to be flying at rather over 800 mph, because if it remained at 760 mph it would be operating steadily very close to the sonic condition which would probably be uncomfortable and undesirable.

Perhaps this is being pessimistic and future developments will be such that it will be quite practicable to fly very close to a Mach number of 1. However, this is one of the design problems which will affect the operation of aircraft very seriously indeed and will affect their flexibility one way or another.

As far as altitude is concerned, the operator finds no operational advantage in flying higher than 30,000 ft except in very special local storm conditions which might push him a little higher. So altitudes above 30,000 ft are not asked for by the operator. If they are flown, they are flown because the design of aircraft makes it necessary. Any cleverness in design which will bring the aircraft down to 30,000 ft will be welcomed by the operator because it will increase his flexibility and decrease the likelihood of anoxia under conditions of failure of some of the equipment.

The operator will still want a parallel body for the cabin of the aircraft. If it has to be pinched in, for aerodynamic reasons, he will want it to be done so cleverly that passengers will not notice it.

Capacity and frequency

Should the supersonic aircraft have more or less passenger capacity than the subsonic aircraft it replaces? This is probably the most difficult airline problem. It depends not only on the cost per seat-mile, as indicated above, but on the optimum frequency and the actual growth of travel. If the cost per seat-mile is much higher than now, will people still pay more money because the supersonic aircraft is the latest and, therefore, the best thing to travel in? In the past, airline experience has shown that people will travel in the faster and more modern aircraft, even if it is less comfortable than the older aircraft, but so far it has not been necessary to raise the fares on the faster aircraft. Almost every time a big speed increase becomes available, the question arises whether it is worth a higher fare. Often airlines decide that it is worth a higher fare, but in fact higher fares are hardly ever charged. I think the odds are that the fares will remain the same even if the productivity is not as great, as long as the new aircraft can break even at an acceptable load factor. On this assumption, it is safe to say that people will travel by this machine and they will not be put off by the high speed or the relatively high altitude.

Nobody knows what the optimum frequency is because it depends on local conditions and a lot of factors that cannot be calculated. It has been said that the frequency of a trip ought to be of the order of its length; in other words, if it takes one day to get to a place, there ought to be one trip a day, and if it takes two hours to get to a place, there ought to be one trip every two hours. If at the moment we have a block speed of 250 mph and this aircraft under consideration gives a block speed of 650 mph, we are getting there 2½ times as fast and it means that under this theory

the frequency ought to be 2½ times over any given route.

If we are talking about 1967 for this aircraft, what can we say about the density of traffic? Will there be many more people travelling or just a few more? If you take a pessimistic view of the past and assume that the traffic increases 10% per year, there should be about three times the number of people travelling in 1967 than there are today.

Since we have cut the journey time by almost one-third, it becomes clear that we need aircraft of about the same capacity that we now operate, but at three times the frequency. Three times the frequency, in many cases, would be an absolute godsend to the airline, particularly in Europe, because Europe suffers strongly from low usage of its lines. In other words, whereas many American airlines cover their total route mileage over 20 times a day, B.E.A. covers its total route mileage only about 3 times a day. On the other hand, maybe the traffic won't increase that much and, again, passengers may want somewhat greater comfort in the future, although you might well say that because the air-time is less they should need less comfort.

As a further guess, one can assume from past experience that the supersonic aircraft will probably not be comparable in cost unless its capacity is considerably larger than that of existing aircraft. The final result will, I think, be that we will have to have them bigger than those at present in use, maybe 150-seaters, just to get the cost down, and that we will not be able to increase the frequency as much as we would want, nor will we increase the usability of our network as much as we should. Our only hope, therefore, lies in a greatly increased travelling public, if we are to fly as fast as we think we must, at reasonable cost.

Shape

Of course, I cannot say what these aircraft will look like because they have not been designed, but there is some evidence that it will be necessary to have fuselages which, for a given diameter, will be about twice as long as those now being designed for new subsonic aircraft. This means that instead of a diameter/length ratio of 1/10, it will be 1/20.

If we want to get 150 passengers into such a fuselage, we find that we cannot put them more than 4 abreast, on the usual assumption that the passengers take up about 60% of the total fuselage length. This will mean 37 rows of seats 4-abreast and a fuselage length of about 180 ft and this assumes not excessively wide seats. If a more roomy interior is required, that is, a wider fuselage, it will have to be longer still or it may be necessary to go back to 3-abreast, that is, two on one side and one on the other. This presents a new and very difficult problem to the operator and indeed to the passenger, because he might well feel that he was in a tunnel almost long enough to reach his destination without it being necessary to fly!

Also, such a long fuselage would be very flexible and, even in very slightly gusty weather, one end would move relative to the other quite a considerable amount. Even now, we find that in long-fuselage aircraft, the front and tail ends move considerably relative to the centre section.

Power and Weight

As I mentioned earlier, the faster the aircraft the more the power plant increases in importance. For the early supersonic transport, about which we are talking, the power plant might be a combination of turbojet and ramjet. No ramjet can power the take-off because it cannot function at low speeds. It can only take over at above 600 mph. The ramjet is light and simple and, therefore, we want to use it as soon as we can. But for take-off and climb, we must have the turbojet. In Zbrowski's studies of the high speed coleopter, he suggests take-off by turbojet and cruise by ramjet. But can we afford the luxury of carrying dead weight about? Whatever we do, the fuel weight is likely to be half the all-up-weight (cf. Viscount at less than ¼ for 1,000 mile ranges), so payload will be scarce on a percentage basis.

A 150-seater turboprop would weigh about 150,000 lb for 1,000 miles range. A 150-seater turbojet (600 mph) would weigh about 200,000 lb. A 150-seater supersonic transport would weigh at least 350,000 lb for 1,000 miles range and cost $9,000,000 to $12,000,000.

What sustains all this fuel and power and the small percentage payload? A wing, a relatively little wing, a wing probably not designed for take-off and landing. To take-off and land, we may need quite special things, such as jet flaps, tilting thrust and, in fact, everything needed for the present day STOL schemes, just to get this thing off at all, even with a rather long runway.

NOISE

Probably the most likely reaction to proposals for supersonic airliners is "what about noise?". This is indeed a problem, particularly the sonic bangs. The sonic bang is not heard by the passengers, but it is heard by everyone near the aircraft track on the ground. It is not just one bang as the "barrier" is broken, but a long continuous bang all along the route all the time. Of course, it is heard as only one bang by each static person.

It does mean that it can be a great source of annoyance and, to minimize the effects, it may be necessary to fly much higher than would otherwise be desirable. The quality of this problem is quite unknown. In the U.K., it has been proposed that transport aircraft should not go supersonic until past the coastline. In Canada, the problem is different. Possibly Manitoba should reserve its bangs to Ontario — and vice versa of course.

IMPONDERABLES

If traffic does not increase, none of us will be able to afford to operate supersonic aircraft. It is a shame that a technical advance, such as this, must depend on something which cannot be calculated or promised and which, in many ways, depends on arbitrary non-technical factors, such as local political situations or economic policy, or a "credit squeeze", which means that fewer people travel than would otherwise travel.

What are we to do about this? Can we base our future on such arbitrary things or must we have something really firm on which to base our expensive and laborious

development? The answer to this may be surprising to those not so involved in aviation as we are. Aviation has never had a firm basis on which to develop and never will. This unfirm basis is no worse than it has always been and if people in the past had paid much attention to prognostications nobody would be flying very much today.

The only difference between today and yesterday is that we know somewhat more about the factors involved in estimates looking into the future. Probably the most dangerous thing to do is to believe the estimates themselves.

All this is hardly a pretty picture and you may feel that I am grossly over-confident in my first remarks. But, after all, I have merely mentioned the problems, the unknowns. I have not said they are insoluble and I certainly cannot give you the solutions to what is unsolved. But I do say what is wanted and, as a result, I expect a solution. There is in my mind no doubt that I shall get one, and a satisfactory one, although I may have to wait a little while for it.

IS IT WORTH IT?

My final remarks will be limited to discussing the problem: "Why should we fly this fast?". A great deal has been written about the most economical way of flying between A and B and the suggestion has often been made that the newest aircraft and the highest speeds result only from competition between airlines, spurred on by manufacturers and with no regard to the requirements of the public. The argument involves not only the question of speed, but also such questions as noise and runway lengths. To fly fast, will the public be willing to pay, albeit indirectly, for expensive longer runways and will they be willing to withstand more noise?

The answer is, individually, *No,* but "en masse", *No Opinion.* In other words, the public is not clear — there is no clarion call. So far, they go for what is faster, like sheep if the gate in the fence is suitably disposed or if the slogan is pushed in the right way.

The odds are that the public will be sold on speed and comfort by someone or other, so we might as well supply them. The moral issues implied should be considered and discussed.

McCURDY AWARD

The McCurdy Award will be presented at the Annual General Meeting on the 27th - 28th May, 1957.

It is presented each year

To A Resident of Canada,

For Achievement in design, manufacture or maintenance related to aeronautics.

NOMINATIONS ARE INVITED

Each nomination should include

(a) The name and affiliation of the nominee,

(b) Confirmation that he is a resident of Canada,

(c) A citation of the particular achievement for which the nomination is being put forward, and

(d) The name of the nominator.

The nominee need not be a member of the C.A.I. and the achievement need not have taken place within the last year, though it should be recent.

Nominations should be in the hands of the Secretary not later than the 15th March, on which date they will be handed over to the McCurdy Award Selection Committee.

DESIGN OF CONSOLES AND VOICE COMMUNICATION SYSTEMS FOR AERODROME CONTROL TOWERS†

by Dr. K. K. Neely,* R. E. F. Lewis**

and F/O W. D. MacNamara***

SUMMARY

With the introduction of ultra high frequencies, the number of channels guarded in Control Towers will be markedly increased. The resulting problems were considered and Air Traffic Control procedure and voice communication systems were studied. A mock-up of a Control Tower and associated control consoles was then made and various arrangements and designs were tried out.

The resulting design of control consoles and voice communication equipment for use in Control Towers is reported and principles are stated for the guidance of Control Tower planners.

PURPOSE

The Defence Research Medical Laboratories were asked by the Director of Telecommunications, Royal Canadian Air Force, to study the problems associated with the introduction of UHF and the resultant increase in the number of radio channels in aerodrome Control Towers.

Although the problems raised were mainly those of voice communications, the satisfactory solution of them required consideration of console design and layout, control procedures and working conditions.

Up to the present time, little application of the knowledge available in the fields of voice communications and human engineering has been made in the design and operation of Control Towers in Canada.

METHOD

Because of time limitations and since Control Tower operations are so complex, full scale experimentation in the field or laboratory was impracticable. Therefore, studies were made of the literature pertaining to the separate systems and skills involved and, in support of these studies, surveys were made of military and civil Control Towers in Canada, Great Britain and the United States.

Next, a full scale mock-up of an RCAF Control Tower and its equipment was built. Consoles were designed that would allow optimum use of voice communication equipment, meteorological instruments, airfield lighting controls and other equipments. The mock-up was invaluable as the basis for practical discussions with experienced Air Traffic Control personnel. Various arrangements were tried out and the final mock-up, shown in Figure 1, is being reproduced as a prototype by No. 10 Repair Depot of the RCAF. General drawings of the consoles are shown in Figures 2 and 3[a].

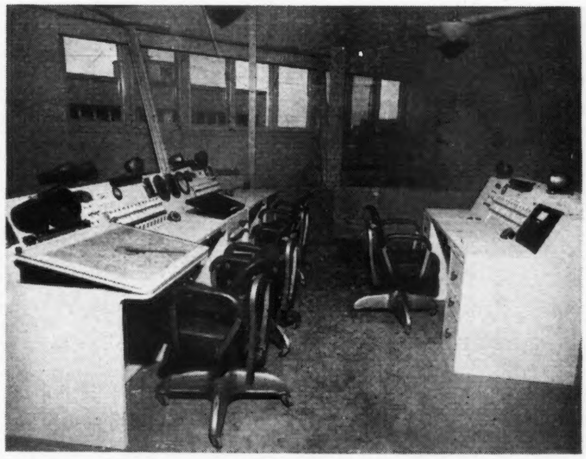

Figure 1
Control Tower console layout

THE ROLE OF THE AERODROME CONTROL TOWER IN AIR TRAFFIC CONTROL

Control Towers are an important feature in the Air Traffic Control system. To effect control, communication must be maintained, not only with aircraft but with Air Traffic Control Centre, Operation Room, Meteorological Centre, Hospital, Fire Hall and other parts of the aerodrome.

Directly related to Aerodrome Control Towers are Air Traffic Control Centres which are responsible for ensuring the safe separation of aircraft flying under Instrument Flight Rules (IFR) within Control Areas. Aircraft movements, from any of the several aerodromes which may operate in the Control Area, are reported to the Air Traffic Control Centre. Periodic position

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***Flying Personnel Medical Establishment, Institute of Aviation Medicine, RCAF.

[a]Detailed drawings of the entire assembly may be obtained from the Defence Research Medical Laboratories, Toronto.

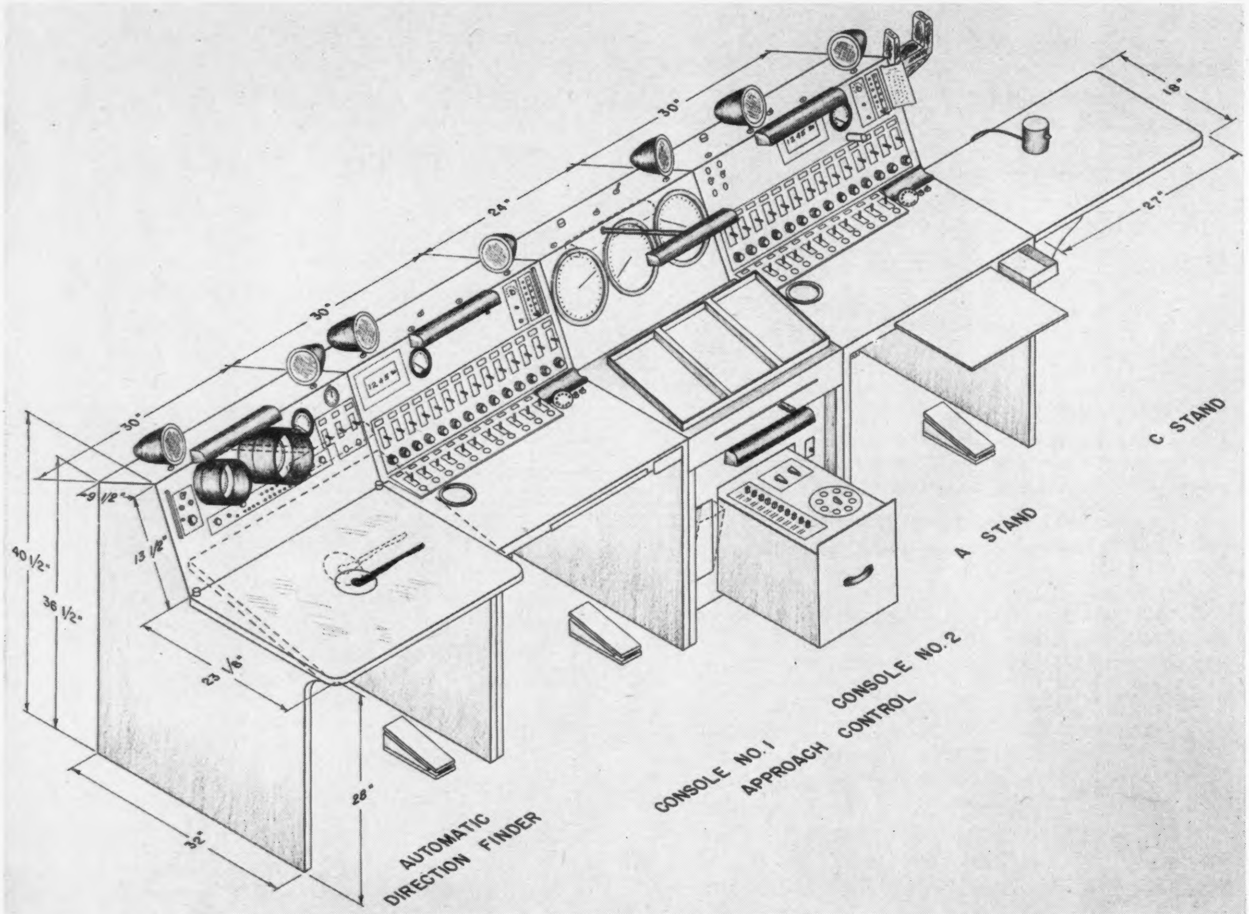


Figure 2
DRML Control Tower console mock-up—ADF, approach control, A stand and C stand

checks are reported to the Centre by all aircraft operating under its authority and, since much of the information is relayed via the Control Towers, adequate communication between Towers and Centres is an important requirement.

PERSONNEL DUTIES

The RCAF staffs Control Towers with officer Controllers and airmen Operators. A typical Control Tower crew consists of an "A" Stand Controller, Approach Controller, Automatic Direction Finder Operator (ADF), "B" Stand Operator and "C" Stand Operator.

For aircraft approaching an aerodrome from outside the local area, the sequence of control is from the ADF Operator through the Approach Controller to the "A" Stand Controller. The ADF Operator passes information to aircraft in the form of bearings to or from the aerodrome. He also assists the Approach Controller in conducting IFR let-downs. The Approach Controller takes over control of the aircraft from the Air Traffic Control Centre and accepts responsibility for the safe separation and flow of traffic arriving at and departing from the area.

The "A" Stand Controller takes over the control of aircraft from the Approach Controller and is responsible for aircraft operating in the immediate vicinity of the aerodrome. The "B" Stand Operator passes and receives flight clearance and position report data to and from the Air Traffic Control Centre. This Operator transfers intercommunication calls to the relevant positions ("A" and Approach Stands) and, in effect, is the Control Tower telephone switchboard operator. The "C" Stand Operator, an assistant to the "A" Stand Controller, records aircraft arrivals and departures.

COMMUNICATIONS

It is recommended that the following procedures and equipments be used to provide controlling, transmitting and monitoring facilities for air and ground communications.

Voice Communication System: Air

(a) Directional loudspeakers terminating frequently-used channels in front of the appropriate listener and possessing efficient speech transmission characteristics.
(b) Directional loudspeakers terminating seldom-used air channels suspended from the ceiling directly above the control consoles.
(c) Not more than two channels terminating at any one loudspeaker. These channels to be used for the same operational purpose.

(d) A boom-type microphone and earphone assembly possessing optimum speech intelligibility characteristics for transmission and reception.
(e) VU meters placed in front of each talker to facilitate their monitoring speech intensities.
(f) Carrier wave operated signal lights provided for each air channel at the Approach Control and "A" Stand positions – green for normally-used channels and red for Emergency and Telescramble channels.
(g) Three-position channel selection switches, not spring loaded. The operating positions: (1) *Up*, permitting reception at the loudspeaker, no transmission, (2) *Middle*, permitting reception at loudspeaker and transmission, (3) *Down*, permitting reception only at the earphone and transmission.
(h) Hand and foot transmit switches, spring loaded. Use of either switch overrides any previous groundline selection.
(i) Manually operated gain controls for each air channel.
(j) A hand held microphone for emergency purposes located at the "A" Stand console and retracting to the console face.
(k) Channel identification cards for emergency VHF/UHF channels sliding into the console face when not in use.
(l) Automatic volume controls inserted in the communication system to maintain desirable sound pressure levels at the loudspeakers.

Voice Communication System: Ground

(a) Boom-type microphone and earphone assembly used for air channel communications to be also used for ground-line communications.
(b) Ground-line signal lights, amber in colour, located at the Approach Control, "A" and "B" Stand positions.
(c) Call warning lights and buzzers at the Approach Control and "A" Stand positions actuated at the "B" Stand position.
(d) Ground-line selection switches, not spring loaded, located at the Approach Control, "A" and "B" Stand positions.

CONSOLE DESIGN AND LAYOUT

Console design was based on anticipated operational requirements with regard to aircraft type and density.

In view of the wide range of operating requirements across Canada, the consoles were designed in sections so that, for aerodromes with limited traffic, control positions can be reduced in number as can the number of operating personnel.

The control of aircraft passes between the ADF, Approach and "A" Stand personnel. Only the "A" Stand Controller and his "C" Stand assistant are required to see aircraft from the tower. However, the side-by-side seating arrangement facing the main runway(s) for all personnel, except the "B" Stand Operator, facilitates the flow of information between controllers and operators.

The "B" Stand Operator does not have to see aircraft. He is, however, required to pass flight clearance and position reports, by hand, to the Approach and "A" Stand Controllers, as well as perform the duties of a

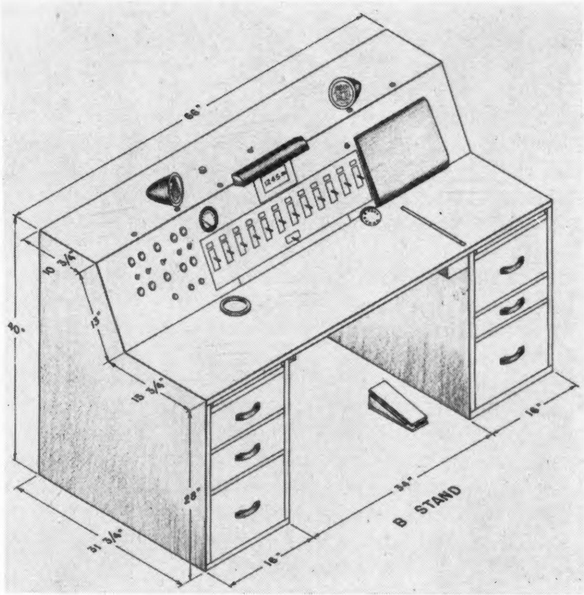


Figure 3
DRML Control Tower console mock-up B stand

clerk and telephone switchboard operator. Consequently, he is positioned behind and facing away from the other personnel.

Controls for voice communication, aerodrome lighting, control tower lighting etc., are positioned for efficient operation. Those controlling similar functions are grouped together and controls are duplicated where necessary.

Careful consideration was given to the angle at which instruments are displayed in the consoles. The wind speed and direction instruments were redesigned for optimum reading. However, appropriately designed direct reading instruments will, when they become available, facilitate instrument interpretation, particularly in the case of the altimeter setting instrument.

For night flying operations the airfield lighting controls, normally housed in the body of the console, are brought to a horizontal position providing easy access to the controls. For both the "A" Stand or Approach Controller, lighting by lumiline tubes are designed to illuminate the console writing areas at between 5 and 10 foot-candles – the intensity to be adjusted by rheostat. The lumiline tubes are shielded so that specular reflections will be minimal.

The ADF Operator is concerned with the interpretation of aircraft bearings. Bearings from the station may be drawn on a glazed plotting board with adjustable slope overlaying on an 8 miles to the inch scale topographical map with a centre (aerodrome) mounted sweep cursor and compass rose. An irregular shape of the back edge of the cursor obviates the possibility of ADF operators plotting bearings on the wrong edge. The disadvantages of specular reflections from the glazed plotting surface at the ADF position are outweighed by the accuracy and procedure orientation resulting from plotting over a local area map.

The 45 flight information stripholders to be used by the Approach controller are contained in a metal tray.

The tray is mounted on a sliding and swivelling mechanism designed to allow the "A" Stand Controller to retrieve the tray from the Approach Controller and so view the strips.

The tandem mounting for binoculars between the "A" and "C" Stand users is introduced as a means of ensuring that the binoculars will be to hand when required. This mounting, together with the angled console top, reduces the likelihood of personnel placing equipment where it may be out of reach or may obstruct vision.

A telephone index pad is available at both the "A" and Approach consoles. Similarly, a printed crash and special instruction sheet, often kept under glass console desk surfaces, is available in a shallow drawer.

Maintaining console equipment has invariably disrupted Control Tower operations. Two features for efficient maintenance are introduced to minimize these interruptions. Firstly, the entire switching assembly for any one air channel or ground-line is removable as a single plug-in-unit. Secondly, the instrument and switching faces of the consoles are hinged to permit technicians to 'trouble-shoot' at the terminal groups.

Facsimile writing equipment would seem to be well suited to the purpose of passing information from the Meteorological Centre to the Control Tower. This installation would reduce the possibility of error, particularly in the communication of altimeter setting data.

In view of the number of necessary warning lights, a press-to-test switch is provided at the Approach, "A" and "B" Stand positions.

A crash-alarm switch is mounted on the top of the console between the Approach and "A" Stand positions.

RECOMMENDATIONS

Air Traffic Control at aerodromes is in the transition stage between simple local aerodrome control and the automatic control of aircraft from the 'airways' through 'Approach' to 'Precision Approach' stage. No matter how simple or complex the control, voice communications and equipment design have to be considered when Control Towers are designed. A most adequate survey of Air Station Control Towers has been conducted by the Human Factors Division, U.S. Navy Electronics Laboratory, San Diego, California[1].

We submit a list of a few of the important features which Control Tower planners should consider. These are:

(1) *Location and Height.* Permitting adequate aerodrome surveillance and identification of the position of aircraft in the circuit and on the ground.

(2) *Shape and Size.* Dependent on the amount of traffic, number of controlling personnel and type of equipment.

(3) *Ambient Noise.* Control Towers located away from high intensity noise areas. Noise attenuation materials (acoustic tile, floor coverings etc.) used in the Control Tower to aid in ensuring adequate voice communication conditions.

(4) *Personnel and Duties.* Number of personnel employed is dependent upon the amount and type of traffic. It is considered that, within the limits of their training, personnel should change duties every two hours.

(5) *Air and Ground Communications.* Adequate facilities should be provided for monitoring and transmitting.

(6) *Lighting.* Consideration of ambient illumination, local lighting and specular reflections.

(7) *Consoles.* Designed for either specific or general operations. Consideration of the design and layout of instruments and controls.

(8) *Air Conditioning.* Room temperature between 70 and 80°F, according to the season, with a relative humidity of between 40 and 60% and air movement of 15 fpm.

(9) *Cold and Hot Water.* Drinking facilities in the Tower Control Room.

(10) *Toilet.* Adjacent to the Control Tower Room and have washing facilities.

(11) *Seating.* Swivel chairs, comfortable, with cushioned seats, backrests and arms.

Increasing the number of radio channels is one of the temporary solutions to the increasing demand for more efficient Air Traffic Control facilities. Unfortunately, the increase in channels is not the same from aerodrome to aerodrome. For example, in certain areas, Control Towers may be found at which only three channels are guarded. On the other hand, an active military jet aerodrome tower will guard up to eighteen channels. In the former case, the number of control positions can be reduced together with the number of operating personnel.

Where 'split control' is used, with the Approach and remote radar scopes mounted in a separate IFR room in the tower, duplicates of the Approach and ADF consoles can also be placed in this area. In addition, so that the different requirements of aerodromes could be met, the console assembly was designed as a series of operating stands, each incorporating the equipment required by the respective controller or operator. This sectional arrangement facilitates mobility of the equipment.

This design would seem to be the practical solution to the question of how to design standard equipment for many aerodromes with widely varying traffic loads.

ACKNOWLEDGEMENTS

We are grateful for the information and advice given us by experienced Air Traffic Control personnel representing the Royal Canadian Air Force, the Department of Transport, the Civil Aeronautics Administration, the Royal Air Force and the Ministry of Transport and Civil Aviation.

We wish to thank Mr. G. Handford, Project Engineer, No. 10 Repair Depot, RCAF Station, Calgary, and Mr. McCarty, Canadian Pacific Air Lines, Calgary, for their original suggestions regarding the console maintenance access design and the approach strip tray swivelling mechanism respectively.

We wish to acknowledge the assistance given by Mr. D. O. Blake, Chief, Engineering Section, DRML, and his staff in the design and construction of the mockups. We also wish to thank Mrs. J. Enkenhus for producing the project drawings.

REFERENCE

(1) Woodson, W. E. et al – *Air Station Control Tower Survey*, U.S. Navy Electronics Laboratory, Letter Report No. 15, December, 1955.

C.A.I. LOG

SECRETARY'S LETTER

SPECIALIST SECTIONS

The Test Pilots Section, which was formed in November, is a pioneer in this experiment in organization, and the formation of other Sections depends very largely on its success or failure. It has made an encouraging start. Coming from as far afield as Halifax and Winnipeg, the Executive Committee and a few other members of the Section recently held a Saturday afternoon meeting at C.A.I. Headquarters to plan their activities, to appoint committees and generally to consider how the thing will work. I attended this meeting and, as the discussion developed, I was impressed by the great possibilities which this whole scheme of Specialist Sections has to offer.

Each Section will be confronted with fairly clearly defined problems, affecting most of its members, and it will be able to concentrate on their solution. It will have to decide the relative importance of these problems and the order in which they must be tackled but, having made this decision, it can get down to business. Much of its work will have to be done by mail and, I hope, through the medium of the Journal (our Technical Forum needs a little exercise) but the fact remains that the Section will provide a medium for discussion, questions and answers, and the general exchange of information among widely scattered people having common interests. This surely is a contribution and one of great value as a supplement to the more diversified programmes of the Branches.

ADMISSIONS

The Admissions procedure has often been criticized as being unreasonably slow but a recent study of some typical cases seems to exonerate the Committee from most of the blame. The principal delay often occurs in obtaining replies from the References and this is something beyond its control. Each applicant is required to name four people as References; the Admissions Committee likes to have comments from at least three of them before it will start work on an application – this seems reasonable enough, if the job is to be done thoroughly and conscientiously. Yet it sometimes takes two or three months to get these comments.

Consequently I would ask all our members who receive Reference forms from me to complete them and return them as promptly as they can. It would be a great help to the Committee and would be appreciated by the people who are patiently waiting to be admitted.

FILM LIST

A Preliminary Issue of the Film List, which I mentioned last September, has been prepared and distributed to the Secretaries of the Branches. It is not a very formidable list but it is a start and I hope that its existence will encourage people to let us know about other films which can be included in Issue 1. For any film to be listed, it is most important that we have all the particulars called for on page 264 of the September 1956 issue of the Journal.

MID-SEASON MEETING

It is time to begin thinking about the new Mid-season Meeting to be held in Winnipeg on the 25th/26th February. This is our first major meeting in Winnipeg and we look forward to a good attendance from Cold Lake, Edmonton and Vancouver, as well as from the eastern Branches. The programme is particularly attractive to people dealing with the operation and maintenance of aircraft under rugged conditions and the fact that conditions in Winnipeg in February are likely to be rugged too, should add atmosphere to the proceedings. However, I happen to know that that famous western hospitality is being sharpened for our benefit. So don your parkas and come along.

INTERNATIONAL MEETING

I.A.S./C.A.I.

THE third International Meeting of the I.A.S. and C.A.I. was held on the 26th and 27th November, 1956, in the Royal York Hotel, Toronto. For the first time in this series of meetings, the Presidents of both Institutes were present.

As in 1955, the highlight of the technical sessions was the presentation of the W. Rupert Turnbull Lecture in the afternoon of the first day. The Lecturer this year was Dr. Simon Ramo and his brilliantly perspective paper is reproduced, in part, elsewhere in this issue.

The registration for the technical sessions was 641 and the Dinner was attended by 562 members and their guests. Unfortunately the weather was very bad, with widespread snow, and possibly the attendance, particularly from the U.S.A., would have been better in less wintery conditions.

Before the beginning of the first technical session, the meeting was opened by Mr. F. H. Keast, Chairman of the Toronto Branch of the C.A.I., and by Mr. W. A. Shrader, Director of Publications of the I.A.S. At the conclusion of the afternoon session on the second day, Mr. E. B. Schaefer, Vice-President of the C.A.I., closed the proceedings for another year.

LADIES PROGRAMME

About 15 ladies took part in a programme of entertainment and sightseeing

Dr. E. R. Sharp, President I.A.S., addressing the members and guests at the Dinner

The two Presidents: Mr. T. E. Stephenson, President C.A.I. and Dr. E. R. Sharp, President I.A.S.

arranged by a C.A.I. Ladies Committee headed by Mrs. Keast. Due to the weather, the sightseeing tour had to be curtailed and instead of the full tour the party paid a visit to Casa Loma, Toronto's "castle".

THE DINNER

Mr. T. E. Stephenson, President of the C.A.I., acted as Chairman of the Dinner on the 26th November. In his speech, Mr. Stephenson welcomed the members and guests of both Institutes and thanked the Chairman and Committee of the Toronto Branch for their hospitality and the excellent meeting arrangements which they had made. He commented on the quality of the programme of technical sessions and on the good attendance despite the weather – he suspected that "a certain sporting event" held on the previous Saturday might have had something to do with it! In a brief review of the state of the C.A.I., Mr. Stephenson mentioned that its membership now exceeded 1,700 and its financial position was sound; he also announced that, at a Council meeting held the day before, approval had been given to the formation of an eighth Branch – at Halifax, thereby completing the trans-Canada chain – and of a Test Pilots Section, the first of the Specialist Sections recently devised to serve specialist members of the Institute; these were significant developments. He then handed the meeting over to Dr. E. R. Sharp, President of the I.A.S.

Dr. Sharp read a telegram, addressed to the C.A.I. by Mr. S. Paul Johnston, Director of the I.A.S., expressing Mr. Johnston's regret at being unable to attend the meeting. Mr. Johnston had to attend the funeral of Major Lester Gardner, the Founder of the I.A.S., who had died on the 23rd November, and Dr. Sharp paid tribute to Major Gardner's great contribution to aeronautics, to the I.A.S. and, indirectly, to the C.A.I. Before introducing the Principal Speaker, the Honorable C. C. Furnas, Dr. Sharp congratulated the C.A.I. on its growth and on the meeting, and urged C.A.I. members to attend the Annual Meeting of the I.A.S. in New York in January.

In introducing Dr. Furnas, Assistant Secretary of Defense, Research and Development, Dr. Sharp said that he was also Director of Cornell Research Laboratories, Chancellor of the University of Buffalo and author of the least known best seller, "The Next 100 Years".

Dr. Furnas spoke of "New Horizons – Military and Civilian". He stressed the importance of raising the standard of living of all peoples of the world, as a means of establishing peace, and described the role which research

The Principal Speaker, the Hon. C. C. Furnas

Some scenes from the meeting

and development has played and must continue to play towards this end. He cited the cooperation between Canada and the United States as indicative of what could be done in this field; it was the duty of the nations which had been successful to spread the benefits to other nations and in this the professional societies, in promoting research, reporting the results and exchanging information, must bear a heavy responsibility. In their effective cooperation in the past, the I.A.S. and the C.A.I. had rendered outstanding service and set an example which should be extended into many other fields.

At the present time, the U.S.A. have 50% of industrial goods and services for only 7% of the world's population. If equality is to be achieved throughout the world, an increase of 750% is required in the use of resources. Allowing for the increase in population in 100 years, this would require 50 times the present developed resources of energy. Research and development towards this is essential as availability of resources to all nations equally is necessary for permanent peace.

As an example of the application of research and development on an international scale, Dr. Furnas gave some particulars of the building of the DEW Line in the Canadian Arctic – "the development of new things and their application to an area of mutual interest".

He defined the four major steps towards attaining peace as mastering the knowledge of the natural world, more and better education, continuing research and development and spreading of the benefits of technology to the rest of the world.

He concluded with the words:

"In the long run the professional groups, such as the Canadian Aeronautical Institute and the Institute of Aeronautical Sciences, will thus make lasting contributions to human welfare and so furnish the basis for a sound and lasting peace".

Dr. H. J. E. Reid, Director, Langley Aeronautical Laboratory, N.A.C.A., was called upon by Dr. Sharp to thank the Speaker.

The Dinner was then adjourned by Mr. Stephenson.

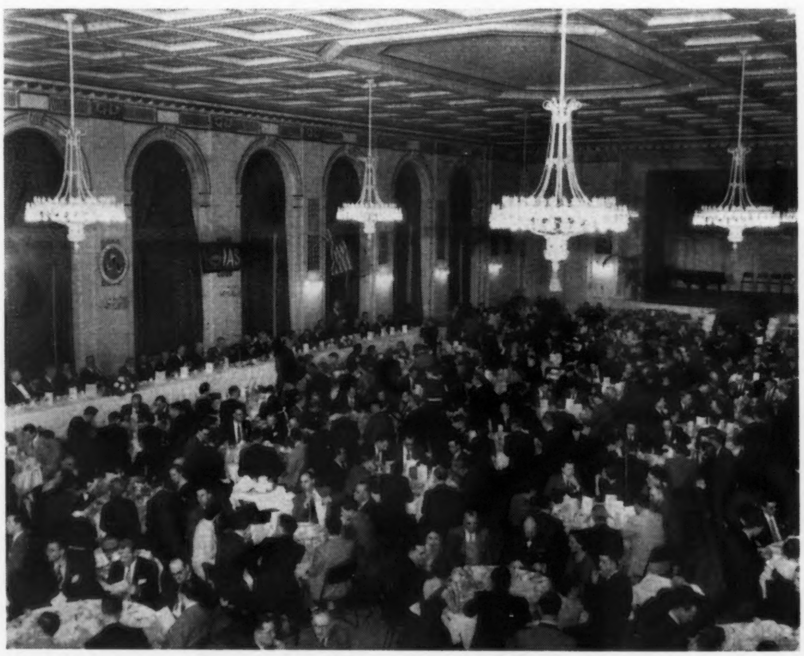
TECHNICAL SESSIONS

The programme of technical sessions is reviewed as follows:

Morning Session, November 26th
Test Flying

Reported by W/C E. P. Bridgland

After the opening of the meeting by Mr. Keast and Mr. Shrader, Mr. W. S. Longhurst, Chief Test Pilot of Canadair and Chairman of the first Session, introduced the first speaker, Mr. D. H. Rogers of Avro Aircraft Ltd. Mr. Rogers spoke on "The Canadian Test Flying Scene" covering the growth of test flying activities in Canada from McCurdy's first flight in the Silver Dart to the present time. He also discussed the need for a test pilots' organization to establish common methods of flight test and pro-



General view of the Dinner

vide a means of exchanging newly acquired knowledge in this field. This need resulted in a general meeting of Canadian test pilots in the spring of this year and subsequently in the formation of a Test Pilots Section of the C.A.I.

Mr. Rogers also spoke of the importance of liaison between test pilots and engineers and the need to reduce the time spent in flight testing an aircraft.

The second lecture scheduled for the morning by Mr. C. E. Myers, Jr., of Convair, on flight testing of high speed aircraft had to be postponed as Mr. Myers had been delayed by weather; Mr. Rogers was, therefore, followed by S/L O. B. Philp, who gave a paper entitled "RCAF Test and Development". S/L Philp covered the history, role and activities of the RCAF in Test and Development. The history of flight testing goes back to the formation of Test and Development Establishment in 1931 and the headquarters of the RCAF's Experimental Unit has remained at Rockcliffe ever since. The main roles of RCAF Test and Development are evaluation and handling trials on new or modified aircraft, acceptance tests and the assistance in developments of interest to the RCAF or other government agencies.

The importance of training of test pilots was outlined, emphasizing the high standard of technical training and flying skill required. The need for team work between pilots and engineers was discussed. Finally, the lecture dealt with the need for avoiding design errors of the past in order to improve the safety of aircraft. The lecture was followed by a lively question period.

Following the two lectures, Mr. Luttman spoke briefly on the organization of the C.A.I., outlining the differences between Branches and Sections and giving details of the formation of the new Test Pilots Section. The meeting was then adjourned for lunch.

Fortunately it was possible to arrange for Mr. Myers to read his paper on the following day, after the Electronics Session. Mr. D. H. Rogers acted as Chairman on this occasion.

Mr. Myers gave a very interesting lecture entitled "Flight Testing of High-Speed Aircraft". In this lecture he outlined many of the present problems. In starting he stressed the importance of simplicity as a requirement for reliability quoting "Murphy's Rule", i.e., if anything can fail it will fail.

He then stressed the importance of making the greatest possible use of any flight test. To this end he stressed the importance of scheduling flight tests and making use of telemetering. Use of telemetering with engineering personnel studying the transmissions permits flight test programmes to be revised and extended in air, thus increasing the utilization of each flight. He also considered that telemetering should be augmented by recording of data in the aircraft to provide a second source of information. This lecture was followed by a very good discussion period.

Dr. Simon Ramo delivering the W. Rupert Turnbull Lecture

Afternoon Session, November 26th

W. Rupert Turnbull Lecture

Reported by W/C E. P. Bridgland

The afternoon session was opened by the Chairman, Mr. J. C. Floyd, who introduced Dr. Simon Ramo of the Ramo-Wooldridge Corporation who spoke on "The Guided Missile as a Systems Engineering Problem".

Dr. Ramo opened the lecture by stating that the problem was either extremely simple or extremely complex. The problem of systems engineering was discussed using the guided missile as an example. The basic points to be considered were the nature of systems engineering, the guided missile and how systems engineering teaching can be improved.

Systems engineering should be creative and should be based on a systematic consideration of the technical requirements and general characteristics applicable to the problem.

The systematic organization of the many phases of the guided missile were divided into physical design problems, guidance problems and the fitting of the missile into the weapons system including maintenance and support.

The need for training engineers in systems engineering was then emphasized with enlargement on the difficulties of the problem.

Morning Session, November 27th

Quality Control

Reported by R. J. Griffin, L. R. Howard and F/S W. G. Massiah

The Quality Control Session was chaired by Mr. H. S. Rees, Chief Aeronautical Engineer, Department of Transport. The first speaker of the Session was G/C R. McMillan, whose paper was entitled "Quality Control Policy in the Royal Canadian Air Force".

G/C McMillan outlined the general policy of RCAF Quality Control. He pointed out that no realistic policy can remain static and it is necessary to alter the policy to meet changing requirements. He then outlined the organization of Quality Control in the RCAF, which consists of three Technical Services Units spread across Canada, each controlling a different geographical area. Within these units there are a number of Detachments located in the plants of major contractors. The RCAF policy is in general to achieve quality control of bought-out aeronautical equipment and service by surveillance of approved firms. Contractors will be approved in any case where it is considered the most efficient

Test Flying Session: (l to r) Mr. D. H. Rogers, Mr. W. S. Longhurst (Chairman), S/L O. B. Philp and Mr. C. E. Myers, Jr.



Quality Control Session: (l to r) G/C R. McMillan, Mr. C. P. Albertson and Mr. H. G. Dickie

and economical way to provide quality control.

The RCAF management policy is to avoid as much duplication of inspection as is possible by putting the onus of actual inspection on the contractor. G/C McMillan concluded his lecture by voicing a need for a purely Canadian Quality Control Society to provide a medium of exchange of ideas and opinions related to quality control between the industry and the RCAF. He felt that Canadian industry should sponsor the formation of such an organization.

The second paper of the Session was entitled "Applications of Ultrasonics in Aircraft" and was delivered by Mr. C. P. Albertson.

Mr. Albertson stated that the introduction of ultrasonic testing has greatly improved the chances of detection of injurious defects in material. This medium of inspection can be used on either ferrous or non-ferrous material, and methods and standards have been devised to detect and accurately measure sub-surface defects.

The sound waves are produced by an electro-mechanical transducer or more simply a quartz crystal supplied with electrical energy and are introduced into the material by either the contact or immersion method. The laws of reflection and refraction of light waves apply to sound waves and discontinuities causing interruptions in the sound wave pattern which, when converted electronically, show as "blips" on the sonic instrument. These defects can be measured by comparison with known defects in reference test blocks.

Ultrasonic examination of raw material has enabled the manufacturer to improve the quality of his product and also assures the finished part designer of greater conformance to required strength specifications.

The detection of defects in material such as duralumin plate, rolled and extruded bar stock, hand and closed die forgings and some extruded shapes has resulted in large savings before expensive machining and fabricating operations. Sonic testing represents a notable advance in the field of non-destructive testing.

The last paper in this Session was delivered by Mr. H. G. Dickie and was entitled "Control of Deviating Material". The speaker stated that Quality Review Inspectors had complete control of material from time of receipt to the finished product. When any deviation occurred, Quality Review were the sole judges of action to be taken. The engineering personnel, who gave advice on stress decisions, worked for Quality Review. When a fault such as an operating error, operator's error etc., occurred, the person making the error also had to sign the deviation concurring.

MRB action was only taken when personnel within Quality Review could not agree on disposition, e.g. type of repair, scrap etc.; as a result, MRB was only used approximately four times in a period of six months.

Parts deviating were routed to quarantine. A Quality Review Inspector, specially selected for his knowledge, was given the responsibility of assessing the course of action to be taken. When decided, a disposition was raised and actioned with the assistance of engineering staff of Quality Review, where considered necessary, and at all times with an RCAF Inspector.

If, in the cases where Quality Review engineering and the RCAF staff were consulted, agreement could not be reached, MRB action was requested. No recurring deviations were accepted.

On all occasions positive corrective action was taken immediately by the Superintendent of the department where the deviation originated. This was accomplished by making corrective action part of the deviation form and the action was not complete until this correction block had been signed by the Superintendent.

Morning Session, November 27th

Electronics

Reported by
K. A. Turner and M. le M. Manson

The Electronics Session, held concurrently with the Quality Control Session reported above, was chaired by Mr. G. F. Kelk of George Kelk Ltd. The first speaker of this Session was Mr. M. Block whose paper was entitled "Operational Use of TACAN".

Mr. Block reviewed the general requirements of an Air Traffic Control system suitable for use in handling the large numbers of high-speed aircraft which will soon be in use by commercial airlines. The need to accommodate military requirements was briefly referred to.

TACAN is a radio aid to aircraft navigation which was developed to deal with this problem. Its general adoption for military and civil use is now being undertaken. By 1956 all sites now equipped with VOR will have been provided with TACAN facilities.

Involving both ground and airborne radio equipment, TACAN supplies to the aircraft its position in polar coordinates (range and bearing) with respect to the TACAN station. In providing this information to the aircraft, the new system identifies the aircraft's relative position with an accuracy not available by earlier techniques. This improvement in accuracy is expected to enable the spacing of aircraft on the basis of distance, rather than time, and will thus permit more efficient use of air space.

In the discussion which followed, the role of ground and airborne radar was considered and the relation between this equipment and TACAN explored.

The speaker emphasized that TACAN did not provide all the answers but was a versatile tool to be used in conjunction with other equipment in dealing with the ATC problem.

The paper, "A Survey of the Advantages of Transistors in Air-Borne Electronic Equipment", presented by Mr. E. F. Johnson, was next in this Session and presented a most convincing argument in favour of the transistor.

Initially it was shown that in terms of total input power the transistor effects a saving of some 95% over the vacuum triode equivalent delivering equivalent output power. Most of this saving, of course, is in the elimination of filament heating power. The fact that the stage gains and output circuit distortions are entirely different was lightly passed over.

It was then shown that the volume and weight savings would not be as great as might at first be anticipated because

the auxiliary circuit components such as transformers must, at the present state of the art, be essentially the same size for equivalent power ratings. Furthermore, the package power density must remain low in order not to exceed the limited environmental temperatures which present transistors will endure, thus further limiting the theoretical reductions in size. Nevertheless power, volume and weight economies of some 50% may at the present time be effected in those equipments which may be transistorized.

In the case of the Super Constellation aircraft, it was shown that the foregoing savings are further enhanced by savings in generation capacity, cooling requirements and airframe strength. The net result could be a total saving of some 9.2% in the initial cost of the aircraft. Further savings have been indicated in greatly increased equipment reliability and resultant decreased maintenance.

In the spirited discussion which followed the paper, it became apparent that at the present time excess gain must initially be provided so that the large transistor parameter variations currently encountered could be swamped by the application of large amounts of negative feedback. In general it was felt that transistor uniformity left much to be desired and that concentrated effort was being made to improve the situation. The provision of additional stages was, of course, reflected in somewhat higher initial costs for the transistorized equipment. However, despite these shortcomings, all those present at the Session could not help but feel that the future for transistorized equipment was now secured.

The third paper of the Electronics Session, presented by Mr. B. I. McCaffrey, was entitled "The Airport and Airways Surveillance Radar for Canadian Air Traffic Control".

The speaker started by making out the case for the provision of surveillance radar along the existing Canadian airways system. He suggested that the collection of adequate data on the ground would go a long way towards solving today's and tomorrow's air traffic control problems, particularly in adverse weather. He offered reasons for the choice of wavelength of 23 cms as against 10 cms, although subsequent questioning did not reveal the audience's complete agreement with the reasoning advanced. In this connection, Mr. McCaffrey might have commented appropriately on any change of performance which operation in Canadian weather conditions might produce, such as the effect of "lobing" after a heavy fall of snow or the effect of ice on the ground antenna installation.

Electronics Session: (l to r) Mr. M. Block, Mr. E. F. Johnson and Mr. B. McCaffrey

Nor did he explain how the use of a surveillance radar would provide a 3-dimensional picture of the traffic pattern. It is suggested that this factor will be of paramount importance when dealing with a combination of jet and piston engined commercial aircraft under IFR conditions. So far a full solution to this problem has not been proposed, either by ground based or airborne systems.

Mr. McCaffrey showed the precautions taken to ensure that the surveillance radar ordered for Canada will continue to operate at peak efficiency and described features incorporated to permit the discrimination of moving against fixed targets and to overcome propagation difficulties during heavy rainfalls.

Afternoon Session, November 27th

Missiles

Reported by H. V. Braceland

The afternoon Session was chaired by Mr. G. D. Watson, Director, Weapons Research, Defence Research Board. The first paper presented was "Guidance and Control of Missiles" by Mr. A. G. Carlton.

Mr. Carlton, who is well known for his work on guidance and control of missiles at Johns Hopkins University, first outlined the basic characteristics related to missiles and these comprise guidance intelligence, guidance computing and the auto pilot. The speaker then related the missile location, missile manoeuvers and controlling aerodynamics problems to the aeronautical engineer in the design of the missile itself.

Mr. Carlton explained that the classification of missiles has been developed through five stages:

(1) Preset
(2) Inertial or proportional navigation
(3) Command systems
(4) Beam rider
(5) Homing systems

The speaker then outlined the various aspects of the trajectory framework associated with each of the five stages. This resulted in either single or multiple paths. It was noted that in all of these systems, the beam rider, command guidance, active and semi-active missiles, the noise problem has a great effect and generally upsets most calculations. During the discussion on each classification, Mr. Carlton stressed the requirement for simplified aerodynamics and an auto pilot which would meet all the requirements and yet would be relatively simple, reduced in complexity and reliable.

The next phase of the paper hinged on the guidance control development of missiles. It was stated that development has been from an open loop system to a closed loop operation. Mr. Carlton showed a simplified block diagram outlining these two different systems and, as he pointed out, feed back is essential. In summarizing, Mr. Carlton stressed the following points:

(a) Requirement for simplified aerodynamics and auto pilot.
(b) Reduction in warhead weight should be considered with missiles of greater accuracy; this would minimize propulsion requirement as the drag is decreased with proper guidance and reduction of noise.
(c) The missile is usually a good compromise between aerodynamics and guidance.

Mr. R. D. Richmond presented the second paper of this Session and it was titled "The Technology of Guided Missiles and Its Effect on Industry".

At the outset, Mr. Richmond reviewed briefly the evolution of the guided missile and its use during World War II and he indicated that at this time the weapon can only be effective when it is considered as a part of a weapons system, which includes functions of early warning, target identification, threat evaluation, target acquisition and

tracking and missile operation. He then outlined the conditions which must be satisfied for a perfect interception against airborne targets. These were:

(1) Supplying errorless course headings calculated from instantaneous errorless positions of the target.

(2) The missile must have greater speed and manoeuverability than the target, must be equipped with errorless guidance and control and have a perfectly reliable warhead.

(3) The weapons system must be immune to all forms of countermeasures.

(4) Various elements and computers in the weapons system must be programmed correctly.

Regarding the above requirement, Mr. Richmond outlined the necessity for a systems engineering concept and he explained this more fully, showing a diagram outlining a simplified weapons system organization chart.

The speaker then explained the various classifications, outlined various definitions for information and gave specific examples including figures and photographs of various types.

The next consideration was the design of the missile itself and to illustrate this Mr. Richmond showed a figure illustrating a hypothetical guided missile and the units which it contained. Added to this, Mr. Richmond explained and defined the homing system and its operation was, he pointed out, the physical complexity of the systems which contributed to the complete missile and he showed that a missile having a total volume of 5 cu ft has approximately 5,000 parts. The majority of these parts are contained within 3 cu ft.

One of the most interesting phases of the discussion referred to the problem of producing a reliable missile. In order to enhance reliability, the missile should, firstly, be designed using reliable and proven components, materials and techniques and, secondly, the manufacturing procedure should be formulated around rigid quality controls. Mr. Richmond indicated that to measure the reliability of a given component on the operation statistical methods may be used. In reference to reliability, Mr. Richmond indicated that a missile having 5,000 parts and 4,000 connections might be assumed to have 9,000 possible sources of failure, each of which by itself may be responsible for a complete missile failure; in order to obtain missile reliability of 62%, the reliability of items must be in the neighborhood of 99.99% and, in fact, reducing the number of items by a factor of ten only reduces the reliability by .05% approximately. Reliable components are therefore extremely important.

The speaker then related problems of development and manufacture, flight testing and, in general, all testing required in order to relatively minimize the risk of failure of individual missiles. Mr. Richmond pointed out the requirement for development time and production time and indicated that tooling and test equipment must be provided some time before the production stage.

The third paper of this Session was titled "A Method for Evaluating Jet-Propulsion-System Components in Terms of Missile Performance" and was presented by Mr. R. Luidens. The speaker first outlined the complex problems required in order to evaluate jet-propulsion-system components in guided missiles and he specifically noted that the purpose of his paper was to present a simple method of estimating the missile performance when only the component performance is known. He also added that the paper would discuss examples illustrating the application of the proposed method. Mr. Luidens stated that he must assume a relatively good missile with the pressure recovery at the inlet and the altitude parameter staying constant, in addition to the thrust coefficient being constant.

The method, therefore, is capable of handling any components in the installed engine; however, the paper was primarily concerned with engine air inlets and exhaust nozzles.

In order to illustrate the various equations and the method described, a discussion of the range equation was made in detail and the pressure recovery at the inlet was taken as the variable under consideration.

It was pointed out that in order to maximize range the product of the lift/drag ratio times the specific impulse should be maximized. This was outlined in a figure which plotted range parameter (L/D)I against altitude parameter, weight over ambient pressure. In plotting in this fashion, the ambient pressure decreases a corresponding amount with fuel consumed and the ratio remains constant; therefore, the maximum point depends only on the airplane design and not on the fuel loading aboard. Once again it was mentioned that a reasonably good airplane is assumed to begin with and the effect of making a small change to an engine component of this airplane is to be evaluated.

Consideration was given to what must be done to the engine in order to maintain a constant thrust coefficient and what these changes do to specific impulse. In order to explore this condition, a plot was shown giving engine performance as specific impulse against the thrust coefficient, where the intermediate variable is the engine combustor temperature. It was stated that if the combustor temperature is held constant after the pressure recovery has been increased both the thrust coefficient and the specific impulse have increased.

The applications of the methods outlined related to a flight vehicle considered to be a long range ramjet powered missile of fixed size. The gross weight was assumed to be initially 100,000 lb but is allowed to vary somewhat as required by engine modifications. The engine was assumed to have a cruising combustion temperature of 3,500°R. The speaker then went on to cover the various aspects of the method described, that is the inlet diffuser, combustion chamber and exhaust nozzle. With regard to the inlet, it was concluded that at high Mach numbers a good inlet should be compromised more in the direction of low drag than is required at lower speeds. With regard to the combustion chamber and the effect of flameholder, it was observed that the importance of the flameholder pressure loss is a function of the flight Mach number similar to the case of the inlet pressure recovery, that is at high speed greater pressure losses can be tolerated without serious consequences.



Missiles Session: (l to r) Mr. A. G. Carlton, Mr. R. D. Richmond and Mr. R. Luidens

Regarding the effects of nozzle expansion ratio and summing the effect on range of each of the parameters, a curve could be drawn showing the total. Reducing the nozzle exit area from a fully expanding condition results in a range improvement of over 4% and an exit pressure ratio of 1.75; this corresponds to an exit area reduction of 33% from that for full expansion. Further area reductions decrease the range; however, an exit pressure ratio of 3.4, which is an exit area reduction of 58%, still provides as long a range as does full expansion.

It was interesting to note that the speaker stated that the present discussion had emphasized application to ramjet missiles. The method, however, was equally applicable to turbojet aircraft and the work was most useful for workers engaged in research and development of inlet diffusers and exhaust nozzles.

During the discussion period that followed, several points were raised regarding the methods and the calculations and the speaker again reiterated that the flight Mach number was held constant for the equations and that altitude variation was taken care of by a weight reduction which left the engine temperature as a variable, though in the discussions concerned a temperature of 3,500°R was assumed. Regarding the method as applicable to turbojet aircraft, it was stated that it does apply to inlet location and that changes up to approximately 5% in range could be tolerated. A question regarding the varying angle of attack was answered by the speaker by stating that the angle of attack could be held constant by changing altitude again with fuel usage.

Copies of Preprints of the papers given at this meeting, other than the W. Rupert Turnbull Lecture, can be procured from

Institute of the
Aeronautical Sciences,
2 East 64th Street,
New York 21, N.Y.

ANNUAL GENERAL MEETING

The Annual General Meeting of the Institute

will be held in the

CHATEAU LAURIER
OTTAWA

on the

27th and 28th May, 1957

The Programme, which is now being prepared, will include Sessions on

Noise, Materials, Aviation Medicine and Human Engineering, Aerodynamics, Anti-Icing and De-Icing, Flight Test, Design and Structures

as well as the annual Business Meeting.

This meeting affords an opportunity for the presentation of papers by members of the C.A.I. The Council is most anxious to encourage Canadian papers and hopes that any member wishing to contribute to any of the above-mentioned Sessions will submit a summary of his paper for consideration. Such summaries must be in the hands of the Secretary by the 28th February 1957.

BRANCHES

NEWS

Edmonton—Reported by H. E. Davenport

November Meeting

The November meeting of the Edmonton Branch was held at the Auxiliary Officers' Mess, RCAF Station Edmonton, on the 20th November. There were 32 members and guests present and the Chairman, Mr. J. G. Portlock, presided.

The minutes of the previous meeting were read and it was moved by Mr. I. L. White, seconded by Mr. C. W. Arnold, that the minutes be adopted as read. The Chairman then stated that it was probable that a dinner meeting would be held early in the new year and that the C.A.I. President, Mr. Stephenson, and the Secretary, Mr. Luttman, would be in attendance. The Chairman also stated that Mr. C. C. Young would be representing our Branch as Acting Chairman at the Education and Training Committee during the International Meeting in Toronto.

Mr. White stated that, in his opinion, the engineer members of the Institute were not well represented on committees and also suggested that specialist groups be set up to facilitate the exchange of engineering data. Mr. C. B. Falconer next queried if our Branch could collect information relative to western maintenance problems for publication in the C.A.I. Journal.

Due to the absence of S/L J. A. G. Diack, Mr. Portlock next introduced the guest speaker, Mr. F. H. Buller, Chief Design Engineer of the De Havilland Aircraft Co. of Canada. It was pointed out that Mr. Buller was not new to Edmonton for, in the early years of the last war, he played a significant part in the development of Aircraft Repair Ltd., the company which later became Northwest Industries Ltd.

Mr. Buller had chosen as his subject, "Slow Speed, Fixed Wing Aircraft" and dealt with the fixed wing aircraft whose main characteristic was the ability to take-off and alight in small fields and, at the same time, attain as high a cruising speed as possible. An increasing worldwide interest in this type of aircraft was being shown, both civily and militarily due to this ability to operate from small fields. Due to nuclear weapons, which preclude mass troop movements, the military are showing increasing interest in such aircraft and for this purpose further development is occurring.

Various types of slow speed aircraft were next discussed and their limitations explained. It was shown that in some operations the low speed fixed wing aircraft was superior.

To further develop high lift, flap design was being investigated as was also flap-blowing, a device which, according to Mr. Buller, worked but was rather expensive. The principle of flap-blowing and air flaps was explained. The speaker stated that some of the high lift characteristics of the Otter could not be explained and that research was being done to find the answers.

The importance of good aircraft control at low speeds was emphasized and it was shown that at low speeds drag was high and a great amount of thrust was required. Mr. Buller thought that, due to the great amount of power required for low speed take-off, multiple turbines might be the answer with some being shut down after take-off. The turbo also makes air available for air blowing purposes. It was pointed out that little research had occurred on low density structures and that the De Havilland Aircraft Co. had been obliged to do this themselves. Discussion of control showed this to be of a complex nature.

The speaker next discussed a new heavier undercarriage that was being developed for the Otter, for the purpose of reducing the landing run, and new type wheels that would enable operation from soft terrain. A very interesting series of slides were then shown which dealt with testing of the Otter structure and aerodynamic characteristics of this aircraft. Mr. C. C. Young ably thanked the speaker for this most interesting talk.

A discussion period followed, after which Mr. Arnold moved that the meeting adjourn and was seconded by Mr. Robinson. Refreshments were served.

Vancouver—Reported by R. J. McWilliams

November Meeting

Forty members and guests attended a Dinner meeting at the Delmar Supper Club, November 14th. The meeting commenced with a business session which created some kind of record, since it lasted only six and one-half minutes.

The speaker for the evening, Mr. Tex Johnston, Chief Test Pilot, Boeing Aeroplane Company, was introduced by Mr. B. A. Rawson, Director of Flight Development, C.P.A.L. Mr. Rawson skilfully traced the career of our speaker, placing special emphasis on his engineering and flight training and on his close association with jet aircraft development in the United States.

Mr. Johnston chose as his subject "A Test Pilot's view of Jet Transport Design and Development". The theme of his talk was the Boeing family of B-47, B-52, KC-135 and 707 aircraft with which he had been closely associated. He gave credit to German research in swept wing theory, explaining its use in the design and development of the Boeing jet family. The limitations of thin swept wings led to fuel in the fuselage to obtain desired range characteristics and to the need for a new undercarriage system. The tandem gear required a new approach to landing gear retraction. The Boeing jet engine location philosophy was outlined. Engine location necessitated high wing design which, coupled with landing gear design and low speed characteristics, led to the development of outriggers for ground stability.

Changing specifications required greater ranges which could not be met by increased fuel capacity. Flight refuelling developed as the answer. Vulnerability of military aircraft whilst refuelling called for high refuelling rates of the order of 600 lb/min. The pressure required for this rate resulted in the development of the boom and special techniques. Jet aircraft need jet refuellers, hence the development of the KC-135. We were astounded to learn that the U.S. Air Force carries out three refuellings each minute, twenty-four hours a day, week in and week out!

The bicycle landing gear demanded new take-off techniques. Due to the inability of the pilot to rock the aircraft on take-off, the wings have a high angle of incidence, so that the aircraft literally flies off. The price to be paid, of course, is in the landing. With only 10% of the weight on the wheels, brakes are not so hot! With such a wing design, the flap method required too heavy a weight penalty — hence the interest in drag parachutes and reverse thrust devices.

Mr. Johnston spent some time describing the design philosophy of the flexible wing construction. On the B-52, from the static load condition to 1 g flight,

the wing tips deflect 6 ft. Static test requirements call for 6 ft negative and 22 ft positive deflection, without permanent set. Our speaker's droll remarks concerning several experiences under maximum load and speed conditions were most entertaining. Notwithstanding the many advantages, such flexibility has its drawbacks in low speed, high power conditions. Control reversal at low speeds led the Boeing designers some distance from the conventional aileron. The use of lateral spoilers minimizes aileron control size. The determination of Boeing engineers to avoid the use of boosted controls (weight penalty) led to the development of the aerodynamically balanced control surface and the ingenious use of very modern and topical devices, referred to as "Dagmars"! Later developments with the lateral control spoilers provided a very efficient lateral control device at both high and low speeds. They became very efficient drag flaps on landing with no weight penalty. The high, thin swept wing creates a most serious condition in cross-wind landings. A cross-wind landing gear was decided upon, which opened up an entirely new area of problems when re-designing the bicycle or tandem landing gear. Our speaker's very graphic description of the sensation of landing whilst looking over one's shoulder was very well received.

The decision to build a commercial jet transport required drastic and radical changes in design. At the same time, it was desirable to retain the many advanced features discovered in the development of the three ancestors of the 707. Fuel had to be carried in the wings and conventional landing speeds and characteristics were most desirable; high thin wing, outriggers and drag parachute all had to go. The result was a low wing aircraft with conventional tricycle landing gear. A deepened wing root section allowed space for fuel and undercarriage, lowered the wing loading and reduced the landing speed. A conventional angle of incidence, the use of the lateral control spoilers as drag flaps on landing and the tricycle gear ensure that 85% of the weight is on the wheels at the commencement of the landing run and permits the use of a conventional braking system. Later developments of the lateral control spoilers provided hydraulic boosting and, in high speed flight, lateral control is by means of the lateral control spoilers alone. Conventional ailerons, aerodynamically balanced, are manually operated and provide a fail safe device. The ailerons are brought into play with the lowering of the flaps which, together with the lateral control spoilers, provide very satisfactory low speed control characteristics. The result was a high speed long range aircraft, admirably suited to modern requirements, meeting all regulations, fitting present intercontinental route patterns and at home on all the world's major airports.

Mr. Johnston ended his talk with a description of a very recent experience. He flew the 707 from Seattle to Washington, D.C., in 3 hrs 55 mins and returned on the same day in 4 hrs 6 mins — 4,680 miles covered in 8 hrs at an average speed of 580 mph! On returning to Seattle, he found it necessary to depart immediately for New York on one of the major airlines. This trip took him appreciably longer than his return flight earlier in the day.

Mr. Johnston then showed two films, one of the proposed interior of the 707 and one of the various test flights carried out with the 707. The latter, although much more rough and ready, was most interesting since it illustrated very graphically many of the features that he had spoken of. In particular there were several feet of film devoted to the lateral control systems.

The speaker was thanked by Mr. R. J. McWilliams. In expressing the appreciation of all present, Mr. McWilliams referred to the speaker's free and easy manner and his most pleasant speaking technique. The interesting way in which Mr. Johnston had led us through the various development phases was very commendable; as was the ingenuity and inventiveness of the aircraft designers. Our speaker was assured of a very enthusiastic welcome when he returned at some future date.

First December Meeting

The meeting was held in the Officers' mess of 19 Auxiliary Wing HQ, Vancouver, on the 3rd December. Fifty-seven members and guests were present.

The Chairman opened the meeting by explaining that this meeting was called in something of a hurry to take advantage of the opportunity to meet and hear our distinguished guest. It was, therefore, the more pleasurable to see so many in attendance. He gave special welcome to so many guests, particularly to the members of the RCAF, and called for a special vote of thanks to 19 Auxiliary Wing HQ for so kindly providing the meeting place.

Our speaker for the evening was Mr. B. S. Shenstone, Chief Engineer, British European Airways. Mr. Shenstone chose as his subject, "Supersonic Civil Air Transport". In the following hour, we were led through the maze of compromises that Mr. Shenstone envisioned would be required of the manufacturer to meet the specification laid down by the operator. Our speaker did not attempt to design the aircraft, but merely laid out the specification of his fictitious aircraft. His audience was intrigued with the glimpse afforded of the effect such a specification would have on manufacture, operation and transportation, if not our very way of life.

The ensuing hour was devoted to discussion, which adequately portrayed the interest of the audience. Without doubt, this was one of the most provocative, frustrating, certainly thought-provoking evenings we have had in a long while.

The appreciation of the audience was adequately and humourously expressed by Mr. J. A. Gillies, Chief Engineer, Canadian Pacific Air Lines.

Second December Meeting

The December 13th meeting, held in the Aero Club of B.C., was attended by fifty-eight members and guests. The meeting commenced with a business session, the main item of business being the election of the Nomination Committee for the 1957 Elections. The Committee will be:

Mr. H. D. Cameron—Chairman
W/C J. W. McNee
Mr. H. S. C. Dow

The speaker for the evening, S/L W. F. Delaney, and his subject, "Aircraft Maintenance—Past, Present and Future", were introduced by W/C McNee. W/C McNee described the speaker's background in industry as an Industrial Engineer, and his career in the Engineering Branch of the RCAF. He described very humourously the interest of the operator in the subject of the talk and assured the speaker of the closest attention of his audience.

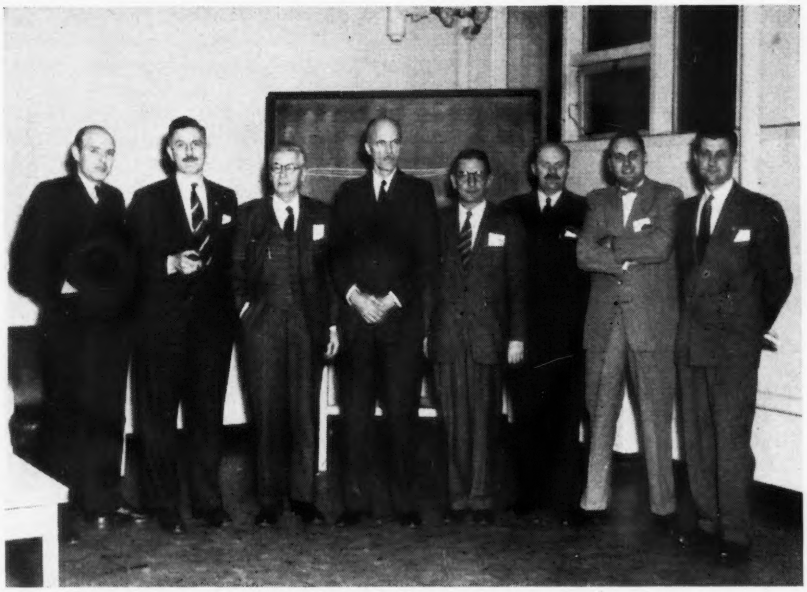
S/L Delaney opened his talk by remarking upon the common interest, in many areas, of the military and the civilian aircraft operator. He moved on to describe the basic problem with the maintenance of aircraft equipment and the essential compromise to be reached between those responsible for operating the equipment and those responsible for maintaining it.

S/L Delaney then outlined the evolution of aircraft maintenance systems and dwelt, at some length, upon the modern approach to detailed planning and scheduling. He described briefly the RCAF's "Calendar" system and the current movement towards the "Opportunity" system, whereby routine work at scheduled intervals is anticipated by "taking the opportunity" of doing it when an unserviceability is experienced. The most radical development foreseen for this new trend is the reduction, if not the elimination, of routine inspection and check. This will, of course, meet with the strongest opposition from the proponents of preventive maintenance. However, it would appear that such a

development provides the only possibility for a major change in evolution.

The speaker laid great emphasis on the need for trained personnel in Maintenance Planning. It is only in very recent years that operators have established separate departments whose function it is to be responsible for the development and planning of maintenance systems. The next step is to staff these departments with men trained in Industrial Engineering, in the application of production methods and in the latest techniques of statistical analysis, work simplification and methods study.

The appreciation of the Branch was expressed by Mr. K. E. Marsden, Chief Inspector, Canadian Pacific Air Lines. In thanking our speaker, Mr. Marsden remarked upon the fact that after many years of rationalisation it appears that we are not to see our goal after all, but merely the vista of newer horizons! This in itself was goal enough, for therein lay true achievement, the opportunity to make a new start and to take part in shaping the future.



At Ottawa, standing in front of Mr. Shenstone's sketch of his visionary supersonic airliner: (l to r) J. L. Orr (Past Chairman), H. C. Luttman (Secretary C.A.I.), H. B. Irving (Consultant, Ministry of Supply), B. S. Shenstone, W. Symmons (Treasurer), G/C W. P. Gouin (Vice-Chairman), S/L G. B. Waterman (Chairman, Programmes Committee) and S/L W. M. McLeish (Secretary)

Ottawa—Reported by S/L W. M. McLeish

November Meeting

The November meeting of the Ottawa Branch was held at the National Aeronautical Establishment, Uplands, on Wednesday, 21st November. The NAE Cafeteria provided ample space and excellent facilities for Ottawa's first attempt at a dinner meeting. Although the turnout was small, it was largely due to the lateness in announcing the details of the dinner meeting and several members, who were unable to attend, indicated their desire to do so at future dinners. Thirty-three members were present at the dinner and they were joined by forty members and guests during the lecture.

Mr. B. S. Shenstone, Chief Engineer, British European Airways, was the guest speaker. His paper was entitled "The Supersonic Civil Transport Aircraft". (*See page 13 – Sec.*)

Mr. Charles Luttman was called upon to introduce Mr. Shenstone and it is of interest to note that Mr. Luttman, who was born in the U.K. and is now established in Canada, was introducing a Canadian, now established in the U.K. Mr. Luttman recalled examples of Mr. Shenstone's previous contributions to the C.A.I. and suggested that Mr. Shenstone was as well qualified as any in the field to anticipate the supersonic airliner.

Mr. Shenstone has a very interesting style of delivery, which enables him to mix facts with humour. His paper on the supersonic airliner was admirably suited to his imaginative mind and at times his whimsical approach to the problem was both stimulating and entertaining. He made several provocative statements and several members could not resist the opportunity of engaging in friendly verbal encounter during the question period. But Mr. Shenstone was not to be ruffled; he merely referred the questioners to his opening remarks and assumptions, which in essence stated that he would not argue whether or not supersonic airliners are necessary, nor did he know how the scientific problems would be overcome; he believed supersonic airliners would become a reality and he had attempted to envisage their characteristics. He cautioned that the advances must be small and pictured the first step into the supersonic as a Mach 1.15 aircraft, which would pose problems for every branch and phase of the aeronautical and supporting industries. For those readers who were not fortunate enough to hear Mr. Shenstone, it will be worthwhile perusing his paper.

The Chairman, G/C W. P. Gouin, was finally forced to request an end to the question period, which was a good indication of the interest displayed by the audience in Mr. Shenstone's paper. Mr. J. L. Orr thanked the speaker and the meeting was adjourned about 10.45 pm.

December Meeting

The December meeting was held at Beaver Barracks on the 5th December and was attended by approximately 80 members and guests. The paper of the evening was entitled "A Canadian Look at VTOL Transport Aircraft" and was presented by two members of the Ottawa Branch, S/L E. E. McCullough, Staff Officer in the Directorate of Aeronautical Engineering, AFHQ, and Mr. P. J. Pocock, Research Engineer, National Aeronautical Establishment.

S/L McCullough discussed the design requirements of a VTOL aircraft to meet Canadian needs, while Mr. Pocock outlined design possibilities in meeting the specification.

S/L McCullough discussed the changes which are taking place in the philosophy of VTOL aircraft, pointing out that the advances in low-speed control and turbine engines make VTOL flight a more reasonable possibility than was previously envisaged. He mentioned briefly the excellent work performed by helicopters but also pointed out their limitations of range, speed, payload and altitude.

He then recalled the reliance of exploration and development on transportation systems, starting with the rivers and lakes, then railroads, the bush aircraft of the 30's and, today, the DC-3 and helicopter. With the aid of a map, S/L McCullough illustrated that heavily loaded helicopters could cover only a small area of Canada's Northern Air Space, under which lie vast natural resources in an environment inaccessible to other than VTOL aircraft. However, by means of circles of 250 mile radii around each improved airfield, he was

able to show that almost complete coverage of the Canadian Air Space could be achieved by VTOL aircraft with such a range. Because of the terrain, required economy of operation and extreme weather conditions, the speaker then dwelt on the need for rugged, economical aircraft with a fast cruising facility and VTOL capability. For those who imagined an STOL aircraft as being adequate for the purpose, S/L McCullough was able to show that, while short take-off might suffice for operations from remote supply bases, a vertical landing facility is a "must" in isolated areas. Hence the answer might be STOVL aircraft, but if equipment is to be recoverable from isolated areas, then VTOL is essential. A survey of the Northern air operators confirmed this specification and a minimum payload of three tons was recommended.

After indicating the existence of a Canadian military requirement similar to civilian needs, S/L McCullough presented a film entitled "The Missing Link", to illustrate the enormousness of the task of establishing a landing strip in the north country. The film illustrated the problems in building a landing strip and radio beacon at Lake Eon, midway between Seven Islands, Quebec, and Goose Bay, Labrador. The film served its purpose very well, and it was easy to imagine how the speaker arrived at the requirement of a fast-moving, rugged, economical, VTOL aircraft, capable of carrying three tons of cargo into and out of isolated northern regions.

Mr. Pocock outlined the design possibilities by emphasizing that his approach was to examine the present trends in transport aircraft and, by extrapolation, to arrive at the conclusion that by 1965 the average transport will cruise at 450 mph at 20,000 ft. In examining the power required for this cruising speed, it can be shown that there will be sufficient thrust available to enable vertical take-off. Mr. Pocock then pointed out that the power facility likely to provide this thrust will be the turboprop, since the turbojet is faced with improving both power and economy during the next decade, and is less likely to succeed than the turboprop. He then discussed the nature of the aircraft configuration, reviewing the current experiments with convertiplanes, tilting wings, tilting engines and tilting the entire aircraft. He envisages a VTOL transport as being feasible by 1965 with the following characteristics:

(a) 500 mile range
(b) 3-5 ton payload
(c) 450 mph cruise at 20,000 ft
(d) 4 turboprop engines
(e) All-up-weight of the order of a DC-3
(f) Conventional fuselage layout
(g) VTOL accomplished by a combination of deflected slipstream; boundary layer control; wing tilt
(h) Operating cost—approximately 50% increase over conventional aircraft on a per-ton-mile basis.

Mr. Pocock presented a short film which showed glimpses of the early flights of Bell Aircraft Ltd.'s VTOL turbojet convertiplane, which achieves conversion from vertical flight by rotating the engines. This film served to emphasize the speaker's reluctance to accept the turbojet as a practicable possibility for a transport aircraft by 1965.

The speakers were thanked by G/C R. M. Aldwinckle, after a lively question period, and the meeting adjourned about 10.45 p.m.

Montreal—Reported by W/C C. R. Thompson

November Meeting

The Montreal Branch held a meeting on the 20th November in the Champlain Room of the Sheraton-Mount Royal Hotel to hear Mr. B. S. Shenstone, Chief Engineer, British European Airways. Mr. Shenstone was introduced by the Chairman, Mr. T. A. Harvie.

Mr. Shenstone's topic was "Supersonic Civil Transport Aircraft" and since it is understood that this paper will be published in the Journal (*See page 13 – Sec.*), it will not be reported here. Mr. J. T. Dyment, Director of Engineering, T.C.A., thanked Mr. Shenstone at the conclusion of his talk.

December Meeting

The December meeting of the Montreal Branch was a social evening and dance, held on the 12th December at the Airlines Cafe, International Aviation Building. The committee, under the chairmanship of Mr. H. A. Ross, with Mr. J. W. J. Truran and Mr. C. G. MacLeod, provided a snappy orchestra, door prizes, favours, buffet and a general good time for about 120 members and their guests.

Winnipeg—Reported by D. C. Marshall

Annual Social

The Winnipeg Branch of the Canadian Aeronautical Institute held its second annual dance at the Assiniboine Hotel on Thursday, November 29, 1956. Nearly one hundred couples enjoyed this most successful event.

December Meeting

On Wednesday, December 5, 1956, the Winnipeg Branch of the Canadian Aeronautical Institute was treated to another of Mr. B. S. Shenstone's stimulating talks on one of the many aspects of aviation. Mr. Shenstone's topic, "The Supersonic Civil Airliner", was in direct contrast to a previous lecture on ultra-light, man powered aircraft.

Mr. Shenstone opened his talk by stating that a supersonic airliner is the next logical step in airliner development. He simplified his approach by limiting his considerations to a medium range aircraft, designed to operate at speeds just above the sonic range. Considering past rate of development and the fact that some authorities feel the rate of development to be increasing, such an aircraft could conceivably be in service within ten years.

The problems of this new type are numerous, but aviation has thrived in spite of many previous problems. One aspect is economics – new aircraft cost more to buy and to fly. The solution seems to lead to larger, heavier aircraft. Low fares, even with faster service, seem to be more important to the public than comfort. Because it is faster, this larger aircraft should cover its routes more often. Mr. Shenstone believes traffic trends indicate that there will be a need for such greatly increased capacity.

Other problems are technical, and will have to be solved by the manufacturer. Runway lengths, noise and flight techniques must be reasonable; no airline wants a "coke-bottle" fuselage. It is probable that long, slim fuselages will be the trend. This will require special treatment to avoid an impression that the aircraft will reach its destination without becoming airborne. When it does become airborne, it should provide motion in a straight line without the added sensations which result from excessive structural deflection.

Some of the issues are really moral. The public will bear the cost of longer runways and complex servicing establishments. Are we justified in planning to use up the world's fuel supply with the tremendous powers being visualized? Who is responsible for any damage, or for assessing the responsibility for damage caused by supersonic aircraft?

Mr. Shenstone's talk stimulated interest and discussion by stating problems without attempting to give many solutions. His vision of the future of our industry is both inspiring and alarming.

In introducing him, the Branch Chairman, Mr. J. J. Eden, spoke of Mr. Shenstone's varied experience and associations. Mr. Shenstone was thanked on behalf of the Branch by Mr. A. S. Jackson. Mr. Jackson pointed out the wide range of equipment now flown by transport operators. He considered Mr. Shenstone's talk a challenge to those who operated the slower aircraft types.

MEMBERS

STUDENTS

Student members who graduated last year are reminded that they must apply for regrading before the 31st March next, if they wish to retain their membership in the Institute. Normally, after graduation, a Student is no longer "undergoing a course of study in a school of engineering or technology" and, therefore, he no longer qualifies for the grade of Student; however, the Council permits him to retain the grade until the end of the fiscal year in which he graduates, i.e., until the end of the following March.

There are certain exceptions to this rule. If a Student, after graduation, has continued a full-time course for his Masters degree, he may retain the grade of Student, though he probably qualifies as a Technical Member and may be regraded if he wishes. But if, since graduation, he has been employed as a paid employee of any organization, he cannot retain the grade of Student, even though he may devote a great deal of his out-of-working-hours time to post-graduate academic studies. Each doubtful case will be considered on its merits and if any Student thinks that his circumstances are such that he still qualifies for that grade, he should submit his case to the Secretary for presentation to the Council.

NEWS

D. R. Buckingham, M.C.A.I., has recently resigned his position as Design Engineer, Avro Aircraft Ltd., to start employment with the Boeing Aircraft Co. in the Field Service Engineering Department.

D. W. Pounder, M.C.A.I., has recently been posted to the Canadian Armament Research and Development Establishment by the De Havilland Aircraft Co.

J. A. Rice, M.C.A.I., has been appointed Technical Representative, Canadian Pacific Air Lines Ltd., at the B.A.L. Plant, Filton, Bristol, England.

K. Grayson, Technical Member, was recently transferred by Trans-Canada Air Lines from Winnipeg to Montreal to fill the position of Power Plant Engineer–Super Constellation.

L. D. Howes, Technical Member, Development Engineer with AiResearch, has been transferred from the Los Angeles Division to the Combustion group of the Manufacturing Division in Phoenix, Arizona.

Major Lester Gardner

Major Lester D. Gardner was not a member of the Canadian Aeronautical Institute but, as founder of the Institute of the Aeronautical Sciences, he was significantly associated with us and his death on the 23rd November cannot be allowed to pass unrecorded in our Journal.

Major Gardner graduated from M.I.T. in 1898 with a Bachelor of Science degree and, following a year of administrative law at Columbia University, he became interested in publishing and spent many years in the publishing business. His company introduced Aviation magazine; it was later sold to McGraw-Hill, who continued its publication for some time before changing its name to Aviation Week.

He served in the U.S. Army Air Service in World War I and later, on numerous aviation committees and official delegations, he exercised considerable influence on the development of aviation in the United States. In 1932, with the help of other aviation leaders, he organized the Institute of the Aeronautical Sciences, with original headquarters at Rockefeller Center in New York. He directed its activities until his retirement in 1946.

It was in these Rockefeller Center headquarters that I first met Major Gardner in 1938. I did not see him again until last July, in the present I.A.S. headquarters, when he delighted in showing me the many letters he had received from all over the world on the occasion of his eightieth birthday. He was extremely interested to hear about the Canadian Aeronautical Institute and, at his request, we have been sending him the Journal ever since.

I feel sure that, had he lived, he would have regarded the International Meetings between our two Institutes with great personal satisfaction.

Ottawa H. C. Luttman

SUSTAINING MEMBERS

De Havilland Aircraft of Canada Ltd. has announced the establishment of an educational and training programme within its organization, under the direction of Professor T. R. Loudon. The purpose of the programme is to contribute to the pool of engineering and scientific personnel available to the Canadian aircraft industry and thereby to shoulder some of the enormous burden now confronting the universities and technological institutes. The programme is designed primarily to encourage technologists to seek professional status but, in addition, graduate engineers are offered the opportunity for doing post-graduate work on a liberal salary allowance; and students from high schools and technical schools and university and technological institute undergraduates are to be employed on summer courses designed to familiarize them with shop practice, processes and procedure in the aircraft industry.

The De Havilland programme was launched in September of this year with the enrolment of 80 engineering department technologists with sights set for the attainment of engineering professional standing. In addition, some engineers have commenced post-graduate studies and a group of 20 started company financed University Extension Courses in advanced mathematics.

For the De Havilland engineering technologist, the programme provides a September to March course of lectures, scheduling two one-hour lecture periods a week. These lectures, designed to prepare the student for examinations leading to professional engineering standing, provide comprehensive theory training in mathematics, applied mechanics, structural design, electricity and electronics. While to date the lecture schedule has been confined to the two one-hour periods a week, future plans are for additional evening lecture periods. For employees wishing to take University Extension Courses, the company will pay the tuition fee where a group of 20 show interest in a particular course.

Professor Loudon stated that applications are being accepted from students in high schools and technical schools and university undergraduates for enrolment in the summer school. The course offered is designed to familiarize them with the operation and production process of an aircraft plant, to give them a basis from which they can assess the relationship between their theoretical training and the practical application of the knowledge they have gained.

Since 1920, the British de Havilland Co. has operated a technical school system to offer training to technologists and university graduates for eventual absorption into the design and production departments. The success of this school is well known in the aviation industry. On the basis of the success of the British company and the excellent results of certain training courses undertaken here over the past two years, De Havilland of Canada decided to act on the proposal for a similar programme here.

Computing Devices of Canada Ltd. has given some interesting particulars of some of the development work under way in its Special Projects Department. Typical of these projects is the nearly completed Cathode Ray Tube Test Station being built for the Canadian Military Electronics Standards Agency. It is as advanced as any similar equipment on the continent and is more compact than any. The CDC design can be used by one man. It fits into three racks taking up no more than 25 sq ft of floor space.

It is intended to be used as a military standard in Canada and as a tool to investigate the problems associated with cathode ray tubes, such as the behaviour of different types of screens. It consists of 46 separate units, nearly every one of which posed some severe design problems for the CDC engineers. Voltage supplies at several levels up to 30,000 volts had to be provided, each with a regulation better than 0.05%. The saw-tooth generators, 1,000 Volt Electrostatic Deflection Amplifiers and the Electromagnetic Deflection Amplifiers, incorporated in the device, have linearities better than 1% and will produce full deflection for any type of cathode ray tubes.

The steadiness of the scanning patterns is such that no movement or jitter is observable even on the largest cathode ray tubes under test when the scanning pattern is magnified many times beyond the screen diameter. Light output can be measured with high accuracy within a range of one to ten million.

The Bell Telephone Laboratories, one of the leading research organizations in the United States, gave CDC the contract for much of the development work on a Radar Spectrum Analyzer and a Bi-Polar Radalarm Test Set. The Spectrum Analyzer is used to measure the energy distribution of the frequency spectrum of transmitted radar pulses. The Radalarm Test Set provides an artificial target for testing a moving target radar installation.

The very accurate measurement of the velocity of artillery shells will be possible to a degree never before achieved when the Canadian Armament Research and Development Establishment takes delivery of a light screen system for projectile velocity measurement from CDC.

Shells will be fired through a series of 16 stations, each consisting of a screen of light only 1/10 of an inch thick. As the shell passes through the light screen, minute changes in the amount of light crossing the screen are measured with photocell amplifiers. In the system, the minimum time taken for a shell to travel from one station to the next one, 50 ft away, is measured with an accuracy of less than one millionth of a second. The overall accuracy of the velocity measurement is 0.02%.

SUSTAINING MEMBERS

Of The

CANADIAN AERONAUTICAL INSTITUTE

1956-1957

Aeroquip (Canada) Limited

Aircraft Industries of Canada Limited

Alloy Metal Sales Limited

Aviation Electric Limited

Avro Aircraft Limited

Babb Company (Canada) Limited

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MEMBERSHIP OF THE C.A.I.

Grade	Qualifications	Annual Dues
Student	Undergoing a course of study at an approved school of engineering or technology	$3.00 ($2.00)
Technician	Engaged in technical work in aviation	$5.00 ($2.00)
Technical Member	Engaged in science, engineering, research, manufacture or operation, in aeronautics or related fields, for 4 years or graduated from an approved school of engineering or science	$7.00 ($4.00)
Member	Engaged in aviation for 8 years and acquired a recognized standing	$8.00 ($4.00)
Associate	Engaged in aviation, though not qualified for technical grades	$8.00 ($4.00)
Associate Fellow	Engaged in aeronautical science or engineering for 10 years and been in responsible charge or made outstanding contribution	$9.00 ($5.00)
Fellow	Been an Associate Fellow for 1 year and attained distinction in aeronautics	$10.00 ($5.00)

MEMBERSHIP REQUIREMENTS

Individual membership of the Institute is divided into seven grades requiring qualifications which are defined in Article 7 of the By-laws. These qualifications are summarized in the table above.

APPLICATIONS

Application for membership must be made on the approved form, which can be obtained from the Secretary, and which must be returned to the Secretary on completion. The applicant does not apply for membership in any specific grade, but each application is carefully considered by an Admissions Committee, who submit their recommendations in this regard to the Council. The Council is the deciding body. On admission the applicant is informed of his grading and the appropriate entrance fee and dues.

ENTRANCE FEES

The Entrance Fee is $5.00. Members in good standing in the R.Ae.S., I.A.S., I.A.T. or O.A.S., on the 1st of January 1954, who were resident in Canada at that time, are admitted without payment of entrance fee. Students and Technicians are also exempt from entrance fee but must pay a transfer fee, which is in effect a deferred entrance fee, when they transfer later on to one of the senior grades.

SPECIAL ANNUAL DUES

Members, who are also members of the R.Ae.S., I.A.S. or E.I.C., or who are resident outside Canada or the U.S.A., enjoy a reduced rate of annual dues. This reduced rate is shown in brackets in the right-hand column of the above table.

SUBSCRIPTION TO C.A.I. PUBLICATIONS

Annual dues include a non-deductible subscription to the Canadian Aeronautical Journal.

INSTRUCTIONS TO CONTRIBUTORS

The Canadian Aeronautical Institute invites the submission of papers, articles and technical notes for publication in the Canadian Aeronautical Journal. Following the practice of other societies, the Institute does not pay for contributions.

Authors should prepare their material in accordance with the following directions:

Manuscripts. Manuscripts should be
(a) Typewritten, double-spaced,
(b) On one side of 8½ x 11 white paper,
(c) With wide margins, approximately 1½", and
(d) With pages numbered consecutively.

Manuscripts must be in final form; the addition of material after acceptance by the Institute cannot be permitted.

Titles. The following form should invariably be adopted:—
(a) Titles should be brief;
(b) The name and initials of the author should be written as he prefers; (Rank or title preceding the name e.g. Wing Commander or Dr., should be included but abbreviations of degrees etc., after the name, should be omitted.);
(c) The name of the organization with which the author is associated should be shown under his name; and
(d) The author's position in the organization, referred to in (c) above, should be shown as a footnote to the first page.

Summaries. Each paper should be preceded by a summary
(a) Of 100 to 300 words, (10 to 35 lines, double-spaced),
(b) In non-specialist language, so far as possible,
(c) Stating the main conclusions of the paper.

Sub-Headngs and Paragraph Numbering. Sub-headings should be inserted by the author at frequent intervals. Paragraphs should not be numbered.

References. References referred to by the author should be treated thus:—
(a) References should be numbered consecutively throughout the paper;
(b) An allusion to a reference should be indicated by a bracketed numeral e.g. "It has been shown by Dr. T. T. James (7) . . . ";
(c) Direct citation of a reference in the text should be written in full, e.g. "As shown in Reference (7) . . . "; and
(d) References should be grouped together in numerical order at the end of the paper, each showing
first, the numerical designation, e.g. "(7)".
second, the author's name, e.g. "James, T. T."
third, the title of his work, e.g. "Aerodynamics and Ballistics"
fourth, the title, volume, issue no, and date identifying the publication in which it appeared, e.g. "R.B.S. Journal, Vol. 7, No. 77, July 1907".

Thus "(7) James, T. T.,—Aerodynamics and Ballistics, R.B.S. Journal, Vol. 7, No. 77, July 1907."

Footnotes. Comments on or amplification of the text should be given in footnotes, appearing at the bottom of the appropriate pages.
(a) Footnotes should be designated alphabetically and consecutively throughout the paper; and
(b) A reference to a footnote in the text should be indicated by a bracketed letter, e.g. "omitting consideration of the third power (c) . . . "

Figures, Tables and Equations. Reference in the text to
(a) Figures and Tables should be given in full, e.g. "Figure 7", but
(b) Equations should be abbreviated to Eq., e.g., "Eq.(7)" or "Eqs.(5) and (6)".

Drawings. Drawings should be
(a) Individually identified by Figure or Table number,
(b) Not larger than 12" x 16",
(c) In black ink on white paper or tracing cloth, and
(d) Capable of being reduced to 3½" wide without loss of legibility of lettering or other detail.

Photographs. Photographs should be
(a) Black and white, glossy prints, and
(b) Individually identified by Figure number, written on a separate piece of paper affixed to the back: writing on the back of the photographs should be avoided.

Captions. Each Figure and Table should be identified by a caption, in addition to its number, e.g., "Figure 12 Theoretical lift distribution".
(a) The caption of a Table should be shown at the top of the Table;
(b) The caption of a Figure should be shown preferably outside the boundary of the Figure; and
(c) A complete list of Figure and Table captions should be given on a separate sheet of the manuscript.

Mathematical work. Only the simplest mathematical expressions should be typewritten; others should be carefully written in ink.
Mathematical work should be
(a) Uncrowded—plenty of space should be provided to accommodate directions to the printer—,
(b) Repeated on a separate sheet of the manuscript, again uncrowded and with plenty of space around each expression,
(c) Clearly written to distinguish between like symbols. e.g. between zero and the letter 'o', and between Greek and English letters of similar form, and
(d) Accompanied by a manuscript "index" of the Greek letters used in the paper, identifying each letter by a name, e.g. "α—alpha".

In addition the following practices should be adopted:
(a) Simple fractions appearing in the text should be shown with a solidus, e.g. A/(B+C) rather than as

$$\frac{A}{B+C}$$

(b) Complicated expressions should be identified by some convenient symbol, if necessary to avoid repetition of the whole expression; and
(c) Complicated subscripts and exponents, and dots and bars over letters or symbols should be avoided.

Symbols and Abbreviations. Consistency is important;
(a) The symbols recommended in the American Standards Association "Letter Symbols for Aeronautical Sciences" ASA Y10-7—1954 should be used wherever practicable; and
(b) Abbreviations of units should be shown in lower case without periods, e.g. lb, mph, bhp, etc.

Mailing. Papers should be mailed to The Secretary, Canadian Aeronautical Institute, 607 Commonwealth Building, 77 Metcalfe St., Ottawa 4, Canada.
(a) Drawings and photographs may be mailed rolled or flat, not folded;
(b) Manuscripts should be mailed flat.

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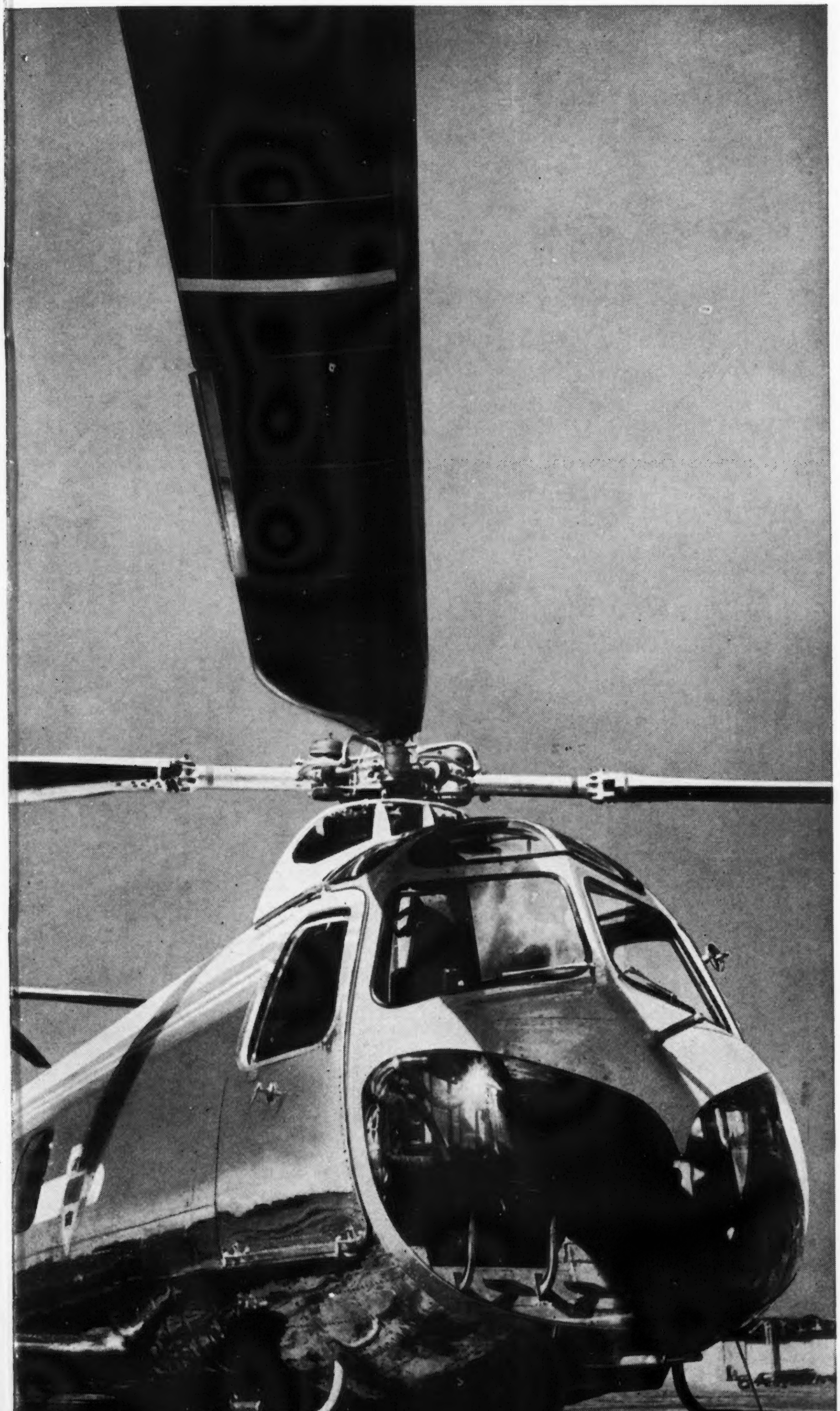

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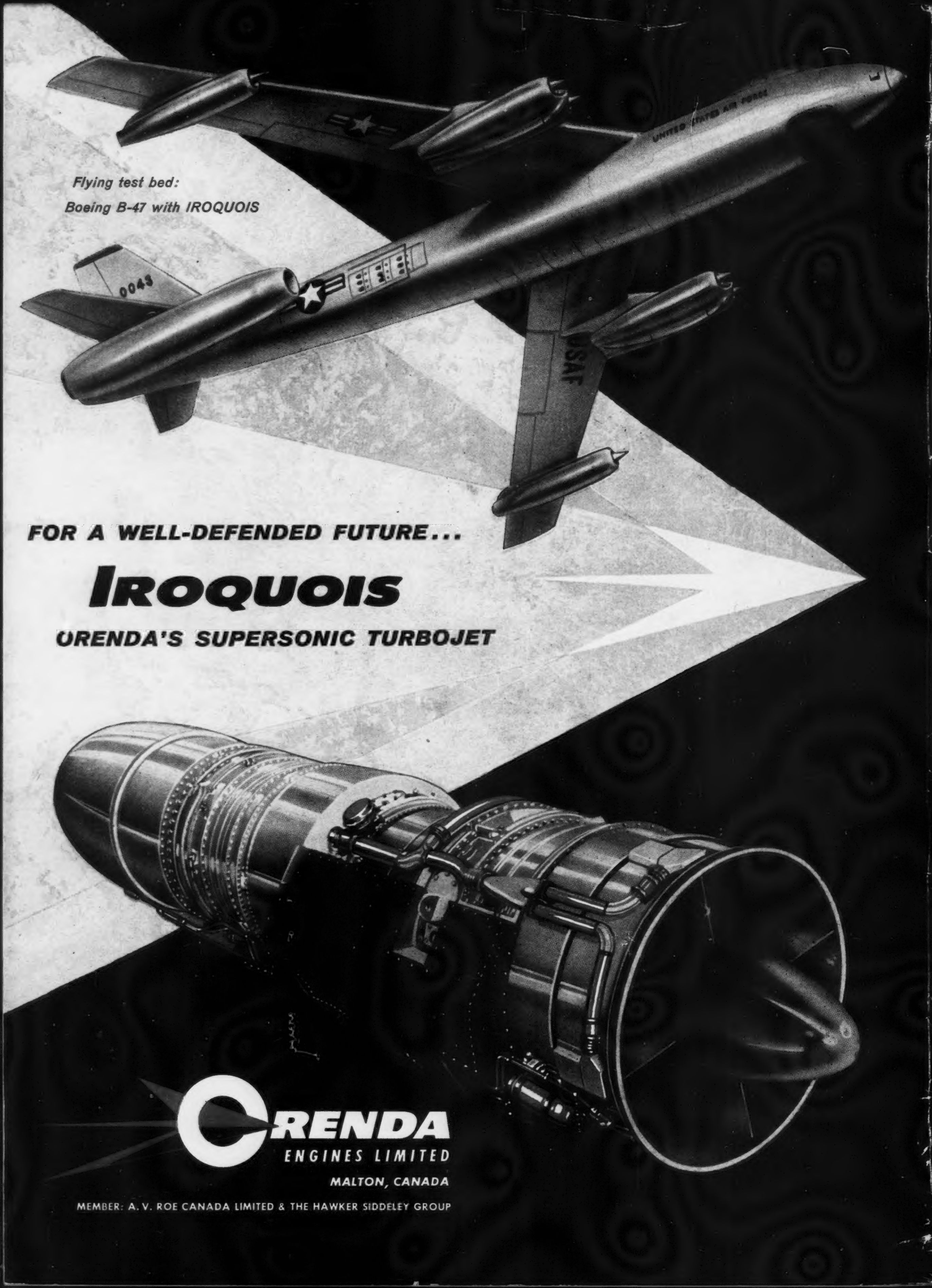
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